THE

FOUNDRY TRADE JOURNAL

WITH WHICH IS INCORPORATED

THE IRON AND STEEL TRADES JOURNAL.

VOL. 29. Thursday, February 21, 1924. No. 392.

PUBLISHED WEEKLY.

Subscription Terms: 15s. per annum.
Foreign and Colonial, 17s. 6d. per annum.
All Subscriptions are payable in advance.

All communications to be addressed to the Editor, or to the Publisher, as the case may be, of
THE FOUNDRY TRADE JOURNAL,
BESSEMER HOUSE, 5, DUKE STREET, ADELPHI,
LONDON, W.C.2.

Contents.

	PAGE
Progress in Testing Cast Iron	143
Grinding of Metals	144
The Institute of British Foundrymen	145
Pig-iron Production in January	145
Award of the Bessemer Medal	145
The Institute of Metals	145
British Standard Specification	146
Correspondence	146-162
The Cylinder Problem	147
Wabana Iron Ore	151
Institute of British Foundrymen	152
The History of the Manufacture of Cast Iron	153
Chemical Aspects of Welding	157
Obituary	157
Modern Automobile Foundry Practice	158
Contracts Open	161
Types	161
Trade Talk	162
Iron and Steel Markets	164

Forthcoming Events.

FEBRUARY 23.

Institute of British Foundrymen (Newcastle-on-Tyne and District Branch):—Ordinary meeting at Newcastle-on-Tyne. "The Operation of a Brass Foundry under Scientific Control." Paper by Francis W. Rowe.

Institute of British Foundrymen (West Riding of Yorkshire Branch):—Ordinary meeting at Bradford. "Some Recent Developments in Foundry Practice," Paper by V. C. Faulkner, M.I.M.

FEBRUARY 25.

Society of Chemical Industry (Newcastle Section):—Ordinary meeting at Newcastle. "Some Aspects of the Physical Testing of Moulding Sands for Foundries," Paper by C. H. Holmes.

FEBRUARY 26.

Sheffield Metallurgical Association:—Ordinary meeting. "Some Notes on the Metallurgical Microscope," Paper by J. H. G. Monypenny.

FEBRUARY 28.

Birmingham Metallurgical Society:—Ordinary meeting at Wolverhampton. "Notes on the Development of Producer Gas-fired Furnaces." Paper by Th. Teisen, B.Sc.

Institute of British Foundrymen (Birmingham Branch):—Ordinary meeting at Birmingham. "Manufacture of Carborundum Wheels and their Uses, etc.," Paper by Wm. Hill.

THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTE OF BRITISH FOUNDRYMEN AND THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION.

Institute of British Foundrymen.

PRESIDENT, 1923-24, Oliver Stubbs, M.I.Mech.E., Openshaw, Manchester.

LIST OF SECRETARIES—

General Secretary: W. G. Hollinworth, 38, Victoria Street, London, S.W.1.
Lancashire: T. Makemson, 21, Beresford Road, Gorse Hill, Stretford, Manchester.
Birmingham: H. James Roe, 33, Herbert Road, Bearwood, Birmingham.
Sheffield and District: W. A. Macdonald, 62, Bannerdale Road, Sheffield.
Scottish: J. Bell, 60, St. Enoch Square, Glasgow.
London: H. G. Sommerfield, Woodhouse Road, N.12.
Newcastle-on-Tyne: H. A. J. Rang, 2, St. Nicholas Buildings, Newcastle-on-Tyne.
East Midlands: H. Bunting, 17, Marcus Street, Derby.
Coventry: J. M. Meston, 37, Melville Road.
West Riding of Yorkshire Branch: A. Love, 232, Gladstone Street, Bradford.

Welsh Engineers' and Founders' Association.

Secretary: E. J. Griffiths, 20, Fisher Street, Swansea.

Progress in Testing Cast Iron.

Elsewhere in this issue we publish the British Engineering Standards Association for testing malleable cast iron. There is nothing very formidable about their clauses, and there is no reason why the average British foundry should not be in a position merely to meet the provisions, but exceed them. It is pleasing to note that mechanical rather than chemical tests are to be met.

The question of the provision of an International test bar for cast iron received attention at a joint meeting of the Gray Iron Committee of the American Foundrymen's Association and the American Society for Testing Materials A 4 Committee on Gray Iron.

The International Test-Bar Committee is composed of eight nations:—Belgium, Czecho-Slovakia, France, Great Britain, Italy, Spain, Switzerland, and the United States of America. Mons. Ramas, of France, is the President, and Mons. Ronceray, the Secretary.

It will be remembered that the French Association favoured the use of the Fremont-Portevin method of testing grey iron castings, and the joint committee decided upon the purchase of such a machine.

It was further decided to do experimental work on round test bars, other shaped test bars being discounted because of the variation due to casting and cooling conditions of such bars. The diameters to be considered are to be 1.2, 1.3, 1.4, and 1.5 in. They are to be cast on end, one in a mould 21 in. long and tested between 18-in. centres. The design of the bar will follow the usual A.S.T.M. specifications. The moulds are to be of either dry sand or cores, and the test bars are not to be tumbled or machined, and, in case of expedition over railways, they are to be packed in sawdust or similar material. Twelve bars are to be cast from a heat, six being sent to the Committee and six to be tested by the maker.

From the British point of view, the most interesting part of the proceedings was the decision to try out the British proposals.

Twelve test bars, moulded singly, on end, in dry sand or core, are to be made by individual foundries. There are to be tests on the three sizes of bars (0.875, 1.2, and 2.2 in. dia.), proposed by the Institute of British Foundrymen's Committee, and special attention is to be given to the transverse testing.

All this work is with the ultimate object of putting engineers in a position to know the strength of the actual casting used. The French proposals relate to the strength of the iron at the place from where the test piece is taken. The American method gives the strength of the iron under certain definite conditions, often but remotely connected to that existing in the casting. The British is an honest attempt to imitate the cooling and other conditions in the casting by their partial and approximate reproduction in the test bars. We hope that as a result of the American tests that their ideas will veer round to the general consensus of, though by no means unanimous British opinion.

When the International meeting took place in Paris it was agreed that unanimity should be reached as to the provision of a universally accepted method for testing cast iron existing as a test piece, and then efforts should be concentrated on finding a means to express the strength of the actual casting. We submit that the latter question is the more important, and if agreement could be reached as to this, the first question would be simple to resolve.

XUM

Grinding of Metals.

New Regulations for the Cleaning of Castings.

With reference to the article with this heading in our issue for July 6 last, the Home Office has now issued draft regulations which the Secretary of State proposes to make, to apply to all factories or parts thereof in which is carried on the grinding or glazing of metals or cleaning of castings.

The Secretary of State is satisfied, as the result of the inquiry referred to in the above article, that when such grinding, glazing or cleaning processes are carried on, more especially where grindstones containing a high percentage of silica are used, further measures are necessary in order to secure a better standard of health and safety among the workers in the industries concerned. He has accordingly decided to give effect to the recommendations contained in the Report of Mr. Macklin and Dr. Middleton, and to issue two sets of Regulations, one applying to the grinding or glazing of metals (other than cutlery or edge tools) and the cleaning of castings, as in the draft Regulations now issued, and the other—which is being issued separately—extending and amending the existing Regulations for the grinding of cutlery or edge tools. For that purpose he has formally certified the grinding and glazing of metals and processes incidental thereto and the cleaning of castings to be dangerous, as required by Section 79 of the Factory and Workshop Act, and in accordance with the procedure laid down in Section 80 of the Act, he is now issuing the proposed Regulations in draft.

Should objections of substance be taken to them, either by occupiers or workpeople, or any other persons affected, these objections will, under the Statute, be the subject of full inquiry by a competent person appointed by the Secretary of State, and the report of the person holding the inquiry will be considered by the Secretary of State before the final Regulations are made. At the inquiry, employers, owners, occupiers and workpeople, and all others concerned, will be entitled to a full hearing.

If, therefore, any person desires the Regulations to be further considered, he should lodge objection in accordance with Section 80 of the Factory and Workshop Act, 1901. Any objection with respect to the draft Regulations by or on behalf of any person affected thereby must be sent to the Secretary of State before March 30. Every such objection must be in writing and must state (*a*) the draft Regulations or portions of draft Regulations objected to; (*b*) the specific grounds of objection; and (*c*) the omissions, additions or modifications asked for. Copies of the draft Regulations may be obtained on application to the Factory Department, Home Office, London, S.W. As the draft regulations differ from the Proposed Regulations, they are abstracted below:—

Regulations.

(1) No racing, dry grinding, or glazing ordinarily causing the evolution of dust into the air of the room in such a manner as to be inhaled by any person employed shall be performed without the use of adequate appliances for the interception of the dust as near as possible to the point of origin thereof, and for its removal and disposal so that it shall not enter any occupied room, and for the purpose of this Regulation the appliances shall not be deemed adequate unless they either include:—(*a*) a hood or other appliance, so constructed, arranged, and placed as substantially to intercept the dust thrown off; and (*b*) a duct of adequate size, air-tight, and so arranged as to be capable of carrying away the dust, which duct shall be kept free from obstruction and shall be provided with proper means of access for inspection and cleaning, and, where practicable, with a connection at the end remote from the fan to enable H.M. Inspector of Factories to attach thereto any instrument necessary for ascertaining the pressure of air in the said duct; and (*c*) a fan or other efficient means of producing a draught sufficient to extract the dust; or are such as, in the case of the particular factory or part thereof, or of the particular manufacture, process or operation in or for which they are used, shall be proved to be at least as effectual for such interception, removal and disposal as such hood-duct and fan would be.

(2) In every room in which wet grinding upon a grindstone is carried on, exhaust and inlet ventilation shall be provided and maintained, whilst work is in progress so as to ensure that the air of the room is renewed not less than 12 times per hour.

(3) Not more than one person shall at any time be allowed to perform the actual process of grinding or glazing upon any grindstone, abrasive wheel or glazing appliance, provided that this Regulation shall not prohibit the employment of persons to assist in the manipulation of heavy or bulky articles at any such grindstone, abrasive wheel or glazing appliance.

(4) Glazing or other processes, except processes incidental to wet grinding upon a grindstone, shall not be carried on in any room in which wet grinding upon a grindstone is done.

(5) Wet grinding upon a grindstone shall not be done except with a supply of clean water, and suitable arrangements shall be provided to ensure the drainage of the waste water from the grindstone trough.

(6) Wet grinding upon a grindstone shall not be done in any room:—(*a*) in which the height of the room, measured from any part of the floor to the lowest part of the top, is less than 10 ft.; nor (*b*) in which the total window area is less than one-sixth of the floor area; nor (*c*) unless all windows are properly glazed and the glass or other material of such windows maintained whole and kept clean.

(7) Hacking or rodding shall not be done unless with an adequate supply of water laid on at the upper surface of the grindstone, and arranged so as to ensure as far as practicable the suppression of dust during the process.

(8) In every room in which racing or grinding upon a grindstone or cleaning of castings is done the floor, walls, ceiling or top and all other parts of the room and fixtures shall be properly cleaned at least once in every three months: Provided that this Regulation shall not apply to the cleaning of castings done upon the foundry floor at the place where the metal for the said castings is poured.

(9) A register containing the dates and particulars of all cleaning done in pursuance of Regulation 8 and the name and the address of the person performing the cleaning, or, when more than one are employed, of the person in charge, shall be kept in a form approved by the Chief Inspector of Factories.

(10) No person employed at grinding, glazing or processes incidental thereto shall spit upon the floor, walls or any part of any room in which grinding, glazing or processes incidental thereto are carried on.

(11) (*a*) In every room in which grinding is carried on there shall be kept permanently affixed a notice specifying the safe working peripheral speed of every class of grindstone and abrasive wheel in use in such room. Such notice shall specify also the speed of the driving shaft or shafts, and the diameters of the pulleys necessary to secure such safe working peripheral speed. (*b*) The occupier or his agent shall, when required by H.M. Inspector of Factories, give all necessary facilities and particulars to enable him to determine the speed of any shaft, pulley or other appliance.

(12) In every room where cleaning of castings is done the floor shall be damped and swept at least once every day. Provided that this Regulation shall not apply to cleaning of castings done upon the foundry floor at the place where the metal for the said castings is poured.

(13) Rumbling shall not be done unless:—(*a*) the rumbling appliance is provided with efficient exhaust draft arranged and maintained so that any dust evolved is prevented from entering any occupied room; or (*b*) such other arrangements are made as shall be proved to be at least as effective in preventing the dust from entering any occupied room.

(14) Sand blasting shall not be done in any room except in an enclosed chamber or cabinet in which no other work is ordinarily performed and at which efficient means are provided, arranged and maintained to prevent the escape of dust to the outside of such chamber or cabinet.

(15) No person shall be allowed to perform sand blasting or to assist at sand blasting in the open air, or be allowed to work within 30 ft. of sand-blasting apparatus in operation in the open air, or be allowed to work or remain in a sand-blasting chamber whilst the sand-blasting apparatus is in operation, unless he is wearing suitable protection helmet, overalls and gauntlets.

(16) There shall be provided and maintained suitable protection helmets, overalls and gauntlets for the use of all persons performing sand blasting or assisting at sand blasting or working within 30 ft. of sand blasting in the open air, or working or remaining in a sand-blasting chamber while the sand-blasting apparatus is in operation.

(17) No person shall wear a protection helmet that has been worn by another person unless and until such protection helmet shall have been thoroughly disinfected.

(18) (*a*) All ventilating plant used for the purpose of extracting or suppressing dust shall at least once in every six months be examined and tested by a competent person, and any defect disclosed by such examination and test shall be rectified as soon as practicable. (*b*) A register containing particulars of such examination and test shall be kept in a form approved by the Chief Inspector of Factories.

(19) There shall be provided and maintained for the use of all persons employed in grinding or cleaning of castings—(*a*) a suitable place or places for clothing put off during working hours; (*b*) a suitable place or places for the storage of overalls.

(20) There shall be provided and maintained in a cleanly state and in good repair, for the use of all persons employed in grinding or cleaning of castings, a lavatory under cover, with a sufficient supply of clean towels, renewed daily, and of soap and nail brushes, and with either—(*a*) a trough with a smooth impervious surface fitted with a waste pipe without plug, and of such length as to allow at least 2 ft. for every five such persons, and having a constant supply of warm water from taps or jets above the trough at intervals of not more than 2 ft., or (*b*) at least one lavatory basin for every five such persons, fitted with a waste pipe and plug, or placed in a trough having either a constant supply of hot water and cold water or warm water laid on, or (if a constant supply of heated water be not reasonably practicable) a constant supply of cold water laid on, and a supply of hot water at hand when required for use by persons employed.

(21) Every person who is employed or engaged in any work to which these Regulations apply shall make full and proper use of all appliances, facilities or accommodation provided for any of the purposes of these Regulations, and shall report forthwith to the owner, occupier, manager or other responsible person any defect in the same.

The Institute of British Foundrymen.

The next general Council meeting will take place in London on Saturday, March 29, at the Engineers' Club, Coventry Street, W.1 (near Piccadilly Circus), commencing at 3.15 p.m. Branches having nominations for membership should send them to Mr. W. G. Hollinworth, the General Secretary, 38, Victoria Street, London, S.W.1, as soon as possible.

Pig-Iron Production in January.

The production of pig-iron in January amounted to 631,500 tons, compared with 626,900 tons in December and 567,900 tons in January, 1923.

The number of furnaces in blast at the end of January was 189, compared with 204 at the end of December, 15 furnaces having been damped down owing to the railway strike.

The production includes 210,800 tons of hematite, 213,000 tons of basic, 142,300 tons of foundry and 34,400 tons of forge pig-iron.

The output of steel ingots and castings increased from 653,300 tons in December to 690,100 tons in January.

Award of the Bessemer Medal.

The council of the Iron and Steel Institute has decided to award the Bessemer gold medal this year to Professor Albert Sauveur, of Harvard University, in recognition of his eminent services in the advancement of the science of the metallurgy of iron and steel. Professor Sauveur hopes to make the journey to London in order to receive the medal at the hands of Sir William H. Ellis, G.B.E., who succeeds to the presidency at the annual meeting of the Institute on May 8 and 9.

Royal Agricultural Society.—The Royal Show is this year to be held at Leicester from July 1 to July 5. The total value of the prizes offered this year amount to over £15,000. The foundry industry, as usual, will be represented by a large show of agricultural machinery.

MR. J. H. LONES, of the Blaenavon Company, Limited, Blaenavon, and Mr. S. W. B. Stephen, of Rolfe Street, Smethwick, have been appointed directors of Bradley & Foster, Limited, Darlaston Blast Furnaces, Darlaston.

The Institute of Metals.

The annual general meeting of the Institute of Metals will be held on March 12 and 13, 1924. The meeting will commence at 10 a.m. each day, concluding not later than 5 p.m. On March 12 the annual dinner of the Institute will be held at the Trocadero Restaurant, Piccadilly Circus, W.1.

Papers to be Presented.

The following communications are expected to be submitted:—

"The Relation Between the Tensile Strength and the Electrical Resistivity of Commercially Pure Copper." (Note.) By W. E. Alkins, M.Sc.

"The Brittle Ranges in Brass as Shown by the Izod Impact Test," by D. Bunting, M.Sc.

"The Cadmium-Lead-Zinc System," by Maurice Cook, M.Sc., Ph.D.

"The Relative Corrosion of Zinc and Lead in Solutions of Inorganic Salts," by J. Newton Friend, D.Sc., Ph.D., F.I.C., and J. S. Tidmus, B.Sc.

"Determination of the Thermal Coefficients of Expansion of Some Commercial Metals and Alloys." (Note.) By J. Newton Friend, D.Sc., Ph.D., F.I.C., and R. H. Vallance, M.Sc.

"Copper-Zinc Alloys which Expand on Solidification," by K. Iokibe, M.Sc.

"The Equilibrium Diagram of the Copper-Tin System," by M. Ishara.

"The Constitution of the Alloys of Copper and Cadmium," by C. H. M. Jenkins, B.Sc., A.R.S.M., and D. Hanson, D.Sc.

"X-Ray Studies on the Copper-Aluminium Alloys," by E. R. Jette, G. Phragmén, and A. F. Westgren, Ph.D.

"The Tensile Properties of Aluminium at High Temperatures," by Thomas Martin, M.Sc., D.I.C.

"The Investigation of a Fatigue Failure of Brass Tubes in a Feed Water Heater—with a Consideration of the Nature of Fatigue," by W. E. W. Millington, M.Inst.C.E., M.I.Mech.E., and Professor F. C. Thompson, D.Met., B.Sc.

"The Effect of Casting Temperature on the Physical Properties of a Sand-Cast Zinc-Bronze." (Note.) By Francis W. Rowe, B.Sc.

"The Aluminium-Copper Alloys. Alloys of Intermediate Composition," by David Stockdale, B.A.

"Note on the Effect of Cold-Drawing and Annealing on Some Electro-chemical Properties of a Low-Tin Bronze," by Stuart H. J. Wilson, B.Sc. (N.Z.), M.Sc. (Vic.).

May Lecture.

After the annual general meeting the next gathering of members will take place, as previously announced, on June 4, at the Institution of Mechanical Engineers, London, in connection with the Empire Mining and Metallurgical Congress, when Dr. F. W. Aston, F.R.S., will deliver the annual May Lecture, his subject being "Atoms and Isotopes."

Autumn Meeting.

The autumn meeting will be held in London from September 8 to 11.

New Members and the London Meeting.

A special Council meeting will be held in London on February 28 for the purpose of considering applications for membership. Those applicants for membership whose forms are in the Secretary's hands before noon on February 28 will be entitled to take part in all the proceedings at the London meeting.

Annual Dinner.

The annual dinner of the Institute of Metals will be held at the Trocadero Restaurant, Piccadilly Circus, W.1, on Wednesday, March 12, 1924, at 7.15 p.m. for 7.30 p.m., under the chairmanship of the President, supported by the Vice-Presidents and Council. If tickets for the dinner (price 15s. each—exclusive of wine) are required, a remittance should be sent to the Secretary, Mr. G. Shaw-Scott, 36, Victoria Street, London, S.W.1.

XUM

British Standard Specifications.

European and Blackheart Malleable Iron Castings for Automobiles.

The British Engineers' Standards Association have issued the following specifications:—

EUROPEAN.

Chemical Composition.

1. The iron shall contain:—Silicon, between 0.50 and 1.00 per cent.; manganese, not more than 0.40 per cent.; sulphur, not more than 0.40 per cent.; phosphorus, not more than 0.20 per cent.

Mechanical Tests.

2. Test bars cast as specified in Clause 3 shall comply with the following tests:—

(*a*) *Tensile Test.*—A tensile test bar cast to the dimensions shown in Clause 4 (*a*) must, when tested in tension without any machining of the gauge length, give the following results:—

Ultimate tensile strength, not less than 20 tons per sq. in.; minimum elongation per cent. in 2 in. not less than 5.

(*b*) *Bend Test.*—A bend test bar cast to the dimensions shown in Clause 4 (*b*) and tested without machining must withstand being bent cold through an angle of 45 deg. round a radius of ¾ in., without showing signs of cracks or flaws.

(*c*) In the event of any of the test bars showing obvious signs of moulding defects after testing, and in the absence of further test bars, the manufacturer shall have the option of submitting one or more finished castings to a destruction test, or to be cut up for tensile and bend tests. If the test or tests prove satisfactory the castings represented shall be accepted.

Provision of Test Bars.

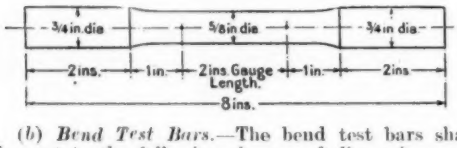
3. (*a*) For castings up to and including 28 lb. in weight the test bars shall not be cast as an integral part of the castings. Test bars for castings over 28 lbs. in weight may, at the option of the purchaser and by arrangement with the manufacturer, be cast as an integral part of one of the castings represented.

(*b*) All separately cast tensile and bend test bars shall be cast in green sand moulds at the same time and from the same ladle as the castings they represent.

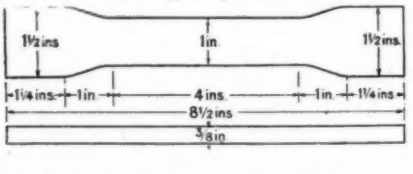
(*c*) In all cases the test bars shall be annealed similarly to, simultaneously with, and adjacent to the castings they represent.

Size of Test Bars.

4. (*a*) *Tensile Test Bars.*—The tensile test bars shall be cast to the following shape and dimensions:—



(*b*) *Bend Test Bars.*—The bend test bars shall be cast to the following shape and dimensions:—



Number of Tensile and Bend Tests.

5. One tensile and one bend test shall be made from every 1 cwt. of castings.

Workmanship and Finish.

6. The castings shall be made in a workmanlike manner, shall be of good finish, and shall conform commercially to the patterns or drawings furnished by the purchaser. The castings shall be free from blow holes and other injurious defects and shall be capable of being machined easily.

BLACKHEART.

Chemical Composition.

1. The iron shall contain:—Silicon, between 0.40 and 1.15 per cent.; manganese, not more than 0.50 per cent.; sulphur, not more than 0.10 per cent.; phosphorus, not more than 0.20 per cent.

Mechanical Tests.

2. Test bars cast as specified in Clause 3 shall comply with the following tests:—

(*a*) *Tensile Test.*—A tensile test bar cast to the dimensions shown in Clause 4 (*a*) must, when tested in tension without any machining of the gauge length, give the following results:—

Ultimate tensile strength, not less than 20 tons per sq. in.; minimum elongation per cent. in 2 in. not less than 7½.

(*b*) *Bend Test.*—A bend test bar cast to the dimensions shown in Clause 4 (*b*) and tested without machining must withstand being bent cold through an angle of 90 deg. round a radius of ¾ in., without showing signs of cracks or flaws.

The other clauses are exactly the same as for European malleable.

Chemical Composition.

The specifications contain the following note on chemical composition:—

The chemical compositions called for in the British Standard Specifications for cast iron and malleable cast iron for automobiles are considered to be of less importance than the mechanical tests required. The limits of the compositions accordingly have been set as wide as possible, and represent the extreme proportions of the different constituents which may be present in a good and serviceable material. Proportions of the constituents outside the specified limits are considered to be inconsistent with the best quality of material. It is considered desirable, therefore, in the use of these specifications that the mechanical properties should be regarded as the main requirements and the chemical composition as an auxiliary check upon the suitability of the material to perform the duties laid upon it.

Correspondence.

[*We accept no responsibility for the statements made or the opinions expressed by our correspondents.*]

Recruiting Foundry Apprentices.

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—During recent years much has been said and written about the education of foundry apprentices and the recruiting of suitable boys for the trade, but relatively so little has been done in this matter that I feel that surely some aid ought to be given to those who are doing their best in this important field.

Where classes in foundry practice are now being held the teachers are in almost all cases greatly hampered by the lack of suitable demonstration models and lantern slides. Most educational authorities will not sanction the expenditure necessary to provide various types of apparatus, etc., because of the small number of students attending the class.

It has occurred to me that teachers of these classes would be pleased to have a central collection of slides, furnace models, and demonstration apparatus which could be secured on loan merely by paying the return postage and cost of packing.

In this matter I have very little doubt that a number of firms and private individuals would be willing to co-operate, and the students would gain not only by the increased facilities, but also by the greater interest in the lectures. This again would no doubt be felt in following sessions by greater attendances at the classes.

The whole subject of the provision of these supplies is one which requires consideration by a suitable committee, and it is my desire to bring the matter up for consideration by the various branch councils of the Institute of British Foundrymen, who I feel are the most suitable body to take up the matter, and interested persons would have little difficulty in forming groups in the various large centres of industry in this country; between the various members of each group suitable collections could be arranged and used.—Yours, etc.,

E. HARWOOD BROWN.

The Cylinder Problem.*

By O. Smalley, M.I.Brit.F.

The scope of this Paper is confined to the cause and elimination of the commoner defects encountered in the manufacture of cylinder castings. Of the problems confronting the engineer and the foundry to-day, the manufacture of sound cylinders and cylindrical castings is possibly the most intense. Faulty cylinders are responsible for the heaviest losses in both the foundry and the machine shop, and many foundries have been financially embarrassed in attempting manufacture. At the present time the number capable of producing sound cylindrical castings is very limited.

To attempt to arrive at the basic principles essential to the production of sound cylinder castings is deplorably difficult; published literature offers little or no solution, and presents such an overwhelming mass of conflicting data that one might be excused in regarding their manufacture as a somewhat hopeless process. Discuss a failure with a skilled moulder, and you find either that he is not responsible for the defect, or that his is an art that has accumulated so many traditions that the possibility of obtaining a sound casting is dependent upon either his past experience or chance. So old is his art, and so saturated is the moulder by his beliefs and opinions unsupported by any actual proof, and so deep-rooted is his conservatism, that science or any innovation is deeply resented. It is a rare thing to find a skilled artisan who has any knowledge of natural science or who understands the fundamentals of his art.

This is the cancer at the root of the cylinder problem. The unenviable position of the foundryman to-day becomes more embarrassing with the restriction of his responsibilities. The construction of the cores or of the mould is being split up into two trades, the moulder and the core-maker. They have little or no voice in the selection of their raw materials, whilst the method of running the casting and the melting of the metal is out of their province. In many instances the work of the skilled artisan resolves itself into purely mechanical labour, but, carrying the traditions of their trade, they are able to bewilder those uninitiated in their art. In some instances, particularly in loam moulding, where the moulder sketches out his own strickle plates and grids, and perhaps constructs his own pattern, a more intricate knowledge of his raw materials and the construction of the mould is essential. Considering the equipment employed by such men, and the class of work they turn out, one cannot but feel a deep respect for their skill. They represent the backbone of the foundry industry.

The manufacture of cylinders is divided into three distinct operations:—(1) Preparation of mould and cores. (2) Melting of the metal. (3) Pouring. The materials used in the construction of the mould comprise moulding and loam sands, facing materials, and the necessary tackle to contain the sands and give it the support and sufficient strength to withstand the temperature and pressure of the molten metal.

The principal defects directly attributable to the mould and core are: Scabbing and flaking, buckling, blow-holes, open grain, mechanical weakness.

(1) *Scabbing and Flaking.*—This results from incorrect venting, incapacity of the mould to withstand the flow of hot molten metal, incorrect drying, low bond value and poor refractory properties, all of which are traced either to the use of inferior sand or to careless moulding.

(2) *Buckling.*—Due to the use of too fine sand or loam, incorrectly prepared sand, too rapid drying, method of construction of mould, too rapid running or beating of the metal in one place.

(3) *Blow-holes.*—Due to incorrect venting, careless preparation of the sand, incorrect drying, patching up, rust or moisture from chills or chaplets and method of running.

(4) *Open Grain.*—Too warm mould or core, low heat conductivity of the moulding sand, method of running.

(5) *Mechanical Weakness.*—Use of wrongly designed chaplets, incorrect adjustment of rate of cooling at change of section, casting of blocks of metal in heavy portions to unify rate of solidification.

Raw Materials.

Moulding Sand.—In general engineering practice it is customary to purchase raw materials to a rigid specification suitable to requirements. In the foundry the prevailing custom, in Great Britain at least, is to order the same as before, or, in the case of sands, to test by feel and by bond, gripping a handful and breaking and examining the fracture by eye. It is with the greatest reluctance that the foundryman will change his raw materials if those in use are giving satisfaction, whilst the potential advantages to be gained from a new material would be difficult to estimate owing to the numerous uncontrolled variables involved elsewhere.

The requirements of a satisfactory mould and core are that it shall form a structure strong enough to handle, resist the temperature, fluxing action and pressure of the molten metal, yet at the same time permit of a free passage of the gas generated in the mould and give to a contraction of metal, and yield smooth and well-finished castings.

The following is an endeavour to formulate the essential properties required of moulding sands for cylinder castings:—Bond, permeability, refractoriness, texture, longevity, heat conductivity, and water content.

Bond.—This is a measure of the cohesion of the sand particles after pressing together in either the green state or after baking. It is best measured by means of the transverse test. The test bar is made in a skeleton core-box 8 × 1 × 1 in. The sand is gently rammed up on a flat steel plate, and any excess is carefully removed. The core-box removed, the test piece is dried and baked at 400 deg. Fah. (205 deg. C.) for two hours and broken over 4-in. centres.

Permeability.—This is the property of allowing the gases to pass through pore spaces. The principle of the apparatus is to determine the time in seconds to draw a known quantity of air through a unit mass of sand. The test piece used is 2½ in. long by 1 in. dia. This is moulded in a suitable core-box, air dried and gently heated to 400 deg. Fah. and baked for two hours at this temperature. When cool it is immersed in a mixture of stearic acid and paraffin wax just molten. Two rapid immersions are recommended, allowing the first to harden before dipping a second time. When the second coat has set hard, the bottom ¼-in. is removed. The test piece is set in a glass funnel with plastic wax and molten wax run in. When firmly set, the top of the test piece is cut open with a specially shaped tool. The funnel is connected to an aspirator of 600 c.cm. capacity, filled with water and the time taken to empty in seconds is recorded as the "permeability" figure, *i.e.*, it is the time taken to draw 600 c.cm. of air through the test piece.

Refractoriness.—This is best determined by heating 5 grams of the dried sand in an electric carbon-resistance tube furnace for 30 minutes at 1,200 deg. C., and then examining under a hand glass or low-powered microscope. Sands showing any signs of fusion or fritting should be rejected.

Texture is determined by a simple mechanical grading using a set of sieves, including a number 20, 30, 60, 90, 100, 120 and 200 with punched round holes.

Heat Conductivity.—This property is closely associated with grain size and the pressure applied in ramming. The smaller the grain and the more compactly rammed, the more rapid the extraction of heat from the metal. It is a property on which little systematic investigation has been published.

D

* A Paper read before the Sheffield, Birmingham and Coventry Branches of the Institute of British Foundrymen and the North-East Coast Institution of Engineers and Shipbuilders.

Water Content.—The uncombined water is determined on 10 grams drying for four hours at 110 deg. C.

Practical Interpretation.

Table I details the properties of three well-known sands of different geological characteristics, as received from the mine and after milling five minutes. These are self-explanatory of the importance of strict control at the mill.

Belgian Yellow.—A highly refractory open sand of good bond, which is not appreciably affected by a light milling.

Birmingham Cemetery Sand.—Well-known red sand. When lightly milled, it is strengthened without seriously affecting the permeability figure. Owing to its nature, however, over-milling should be studiously avoided, because the sand readily disintegrates, and although accompanied by an increase in strength, there is a marked fall in the permeability.

Lenton.—An open red sand, highly suitable for cylinder work. It will be observed that milling does not disintegrate as in the case of Birmingham Cemetery Sand, but unlike Belgian Yellow, its value is improved by a light milling.

Green Sand.—In modern foundry practice green sand moulding is a lost art, and for cylinder castings dry sand moulds are almost universal. On the Continent and in America automobile cylinders are made in green sand moulds, but the contour of the castings is formed from a series of hard-baked cores, a practice which can scarcely be styled "green sand moulding."

If we are to revive this branch of the industry, which is essential if moulding costs are to be reduced under present economic conditions, either more men must be trained as green sand moulders or a "sand" must be found which is "foolproof" and does not require the individual skill of the trained moulder. High cost of labour and mass production militate against the revival of the highly skilled artisan. A green sand mould, made by unskilled labour, therefore, must have the properties of a dry sand mould; it must be hard and compact so that crushing and erosion by the hot metal are avoided; it must be rigid and resist the expansion of the solidifying metal, be freely venting and have a low moisture content.

In normal practice the bond value of green sand, measured by the dropping test, varies between 1¾ to 2¼ in., the permeability to gas 60 to 100 sec., and the water content 6 to 7 per cent.

In the old days this sand was prepared by the moulder himself, who was usually a man of long experience. The modern tendency is to confine the moulder's time to moulding; sand preparation is considered out of his sphere. *If prepared with an understanding of the real requirements of the sand, centralised sand preparation is a step in the right direction.* If done for the purposes of economy, placing in the hands of unskilled labour —which is the common practice of to-day—green sand moulding will always be the uncertain art it is to-day, and a costly method of making castings.

Given a sand of higher bond value than is average, or ramming brick hard, the moulder fears blowing or scabbing, such sand in the past having been proved to be dense and impermeable to gas. In the early stages of development of a "synthetic green sand" which would eliminate dry sand moulds, the dropping test aimed for was 3¾ to 4 in.; that is an exceedingly strong and tough sand, water content 4 to 5 per cent. and permeability figure 50 seconds. A green sand core 8 × 1 × 1 in. could be handled with ease in this sand, and it was more freely venting than the ordinary green sand, which crumbles to the touch.

The first tests were carried out on 100 valve bodies, a design which had given trouble when previously made in green sand. Moulding was done, two in a box, on a jolt ram machine. *The time of moulding was reduced 40 per cent.* The moulds were well-finished, strong and rigid. Touching up and sleeking were unnecessary. When the moulder was requested not to use a vent wire for artificial venting, doubt was cast upon the sanity of the project. This batch of castings came out so successfully that it at once established the value of *sand testing* to the untutored mind and achieved the original object, viz., *to produce a green sand mould by unskilled labour equal to and as foolproof as a dry sand mould.*

The effect of water in the dampening down or tempering of the moulding sand, and the effect of ramming on the venting power, are shown in Tables II and III respectively. Table II shows the effect of varying percentages of water on the venting properties of Mansfield and Erith Loam when made into dry sand moulds. Table III details the effect of ramming on the venting qualities of the same two sands. These tables demonstrate the necessity of rigid control of the water content, and show that, if it is under control

TABLE I.—*Testing of Sands for Dry Sand Moulding.*

Source.	Physical condition.	Temperature and time of baking.	Permeability to gas in secs.	Transverse tests ozs.	Moisture content of sand before use.	Mechanical Grading. Per cent. by weight retained on sieves mesh passes						
						20	30	60	90	120	200	200 to the inch.
Belgian Yellow ..	Tempered ..	400° F. 4 hours.	55	132	10.2	10	2	14	47.5	3	8	15.5
	Milled 5 min. ..	,,	72	136	9.6	—	—	—	—	—	—	—
Birmingham Cemetery	Tempered ..	,,	45	53	7.9	0.13	0.08	5.62	63.58	3.25	16.48	10.86
	Milled 5 min.	,,	76	199	8.4	0.14	0.06	5.45	65.48	1.03	16.96	10.98
	Milled 30 min.	,,	440	608	8.9	0.01	0.08	5.03	56.18	4.70	16.88	17.12
Lenton ..	Tempered ..	,,	46	160	10.5	0.05	0.60	29	41	4	14	11
	Milled 5 min.	,,	60	270	10.9	—	—	—	—	—	—	—

TABLE II.—*The Effect of Varying Percentages of Water on the Permeability of Mansfield Sand and Erith Loam when made into Dry Sand Moulds.*

Sand.	Percentage of H_2O	Permeability.
Mansfield	3 ..	48 secs.
,, ...	6.71 ..	48 ,,
,, ...	13 ..	110 ,,
Erith Loam	6 ..	47 ,,
,, ...	12 ..	80 ,,
,, ...	15 ..	82 ,,
,, ...	25 ..	216 ,,

TABLE III.—*The Effect of Ramming on the Venting Qualities of Mansfield Sand and Erith Loam for Dry Sand Moulds.*

Sand.	Ramming.	Percentage of water.	Permeability figure in seconds.
Mansfield ..	Light ..	6.7	41
	Normal ..	,,	48
	Heavy ..	,,	61
Erith Loam ..	Light ..	11.2	Too friable to test.
	Normal ..	,,	85
	Heavy ..	,,	110

and due care has been exercised in the selection and in the preparation of the sand in the first place, the venting power is not materially affected by excessive ramming.

Loam.

Loams may be placed in three general categories:—(1) Building loams; (2) mould loams, and (3) core loams.

Each is a clayey sand milled with floor sand to a slurry containing 20 to 25 per cent. water, opened by means of sea-sand, coke, ashes, sawdust, cow-hair or horse-dung.

The commonest troubles with loam moulds and cores are flaking of the face on drying or on casting, scabbing or buckling, blowing, contraction cracks, too high bond.

The essential properties required of loam are: (1) Low shrinkage on drying; (2) strength; (3) porosity; (4) permeability; (5) refractoriness; and (6) property of rubbing. The fundamental importance of these and the precise control in the preparation of loam should be patent to all, and yet it is no uncommon practice to have loam prepared as a builder does his mortar. Table IV shows the effect of milling on the strength, permeability to gas and volume changes, of one of the most commonly used loams, viz., Erith. It shows that little mechanical action is necessary

TABLE IV.—*Effect of Milling Erith Loam.*

Time.	Water content.	Transverse strength baked 4 hours at 400°F.	Permeability to gas in secs.	Volume changes after baking at 400°F. 4 hours.
Tempered over night.	21.9	276	730	4.47
Hand milled ..	23	492	927	6.62
Milled 5 mins.	22.8	547	1,700	7.67
,, 15 ,,	21.9	579	1,945	8.25
,, 30 ,,	22.7	604	2,528	8.43

to obtain the desired combination of properties, and that hand milling almost doubles the strength. In ordinary practice, mechanical milling for five minutes gives the best combination of strength and permeability, any longer time than this merely grinds the loam into a finer state of division, reduces the permeability to gas, increases the contraction on drying, and renders it more suitable for use as a cement than a foundry loam.

Table V details the effect of varying the percentage of water on the physical characteristics of loam. It demonstrates broadly the progressive

TABLE V.—*Effect of Varying Percentages of Water on the Physical Characteristics of Erith Loam.*

Treatment.	Per cent. water.	Transverse.	Permeability.	Volume change.
Milled 5 mins. ..	11.4	148	72	1.3
Water added and milled 2 mins.	19.8	530	690	6.62
Water added and milled 2 mins.	21.5	650	2,200	8.31
Water added and milled 2 mins.	28.97	448	1,095	8.67

effect of increasing quantities of water, and emphasises the high importance of its accurate control.

Effect of Rate of Drying.—That the elimination of 20 to 25 per cent. of water from a loam must be conducted with considerable care and without undue haste is quite evident from the volume change figures given in Table V. It is an everyday practice, however, to find a moulder disregarding these precautions. He will sweep a job and have it in the stove within a few hours, and yet is surprised to find it badly cracked or flaked, or lifted bodily from its bricks or plate. Often this is scarcely discernible and difficult to detect, but no matter how slight, the result is a buckled casting.

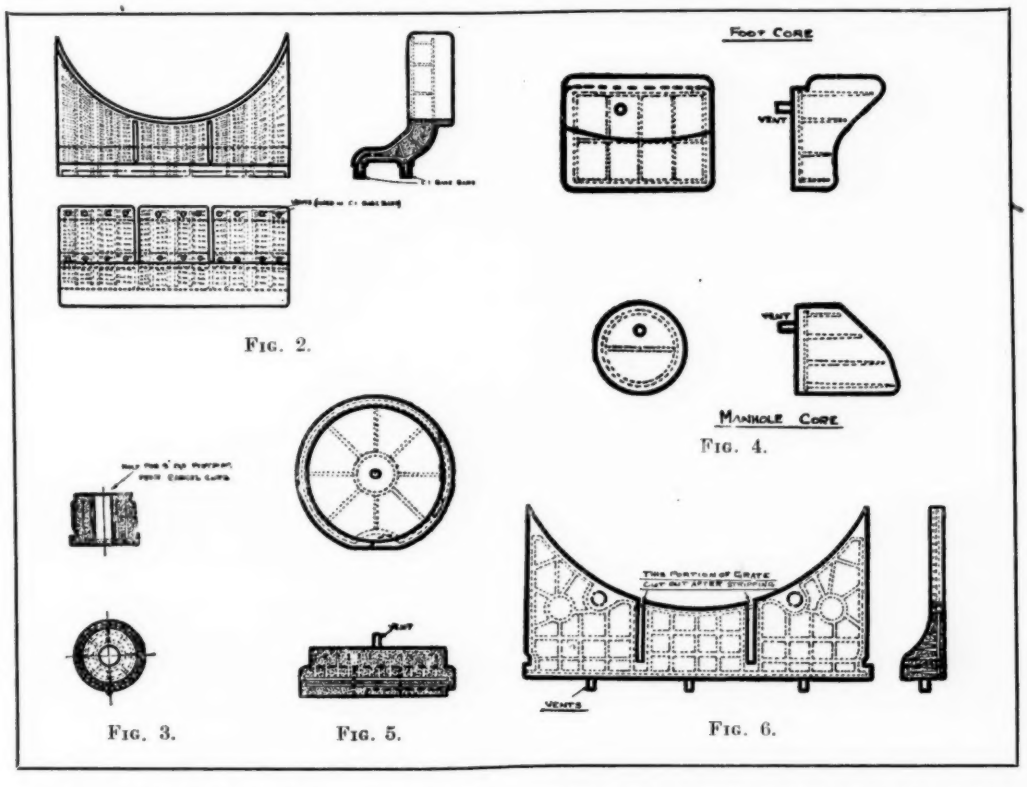


FIG. 2. FIG. 3. FIG. 4. FIG. 5. FIG. 6.

Construction of Moulds and Cores.

In this Paper it is impossible to treat fully the defects resulting from wrong construction of the mould or cores. Starting from a basis, however, that the physical characteristics of the sands used are known and are under control, and that the moulder possesses an elementary knowledge of physics, mechanics and sound practical sense, the commoner defects such as scabbing, flaking, buckling, blow-holes, shrink holes and draws will be greatly eliminated, and the construction of the mould will lend itself to standardisation.

For the purpose of this Paper, we will consider the construction of a large l.p. marine-engine steam cylinder. Figs. 1 to 6 show the cores and method of construction of a cylinder with a dished crown weighing 23 tons. The pattern consisted

XUM

of a few simple strickles, skeleton core-boxes and the necessary wood trappings. The mould was made in sand, the cores in loam. This complex structure was erected with little or no knowledge of the properties of the raw materials used, or of the strength and rigidity of the cores. Yet it had to withstand the strain and stress of 23 tons of molten metal poured into it in 2½ minutes. The metal must flow uniformly throughout the sections without agitation and overlaps, and the gases must pass freely through the vents arranged for them. Neither the sand nor loam must spall, nor must the metal wash away any corner or details of either mould or core. Suffering mass influence, and undergoing a chemical change until completely solid, uniform freezing conditions must be sought, compensations made for both liquid expansion, liquid contraction and solid contraction—which may operate at the same time —and arrangements made to remove the products of chemical action in the metal during solidification.

The mould for such a casting in its details and complications calls for the science and understanding of any mechanical construction of the engineer. Yet the fate of such castings hangs

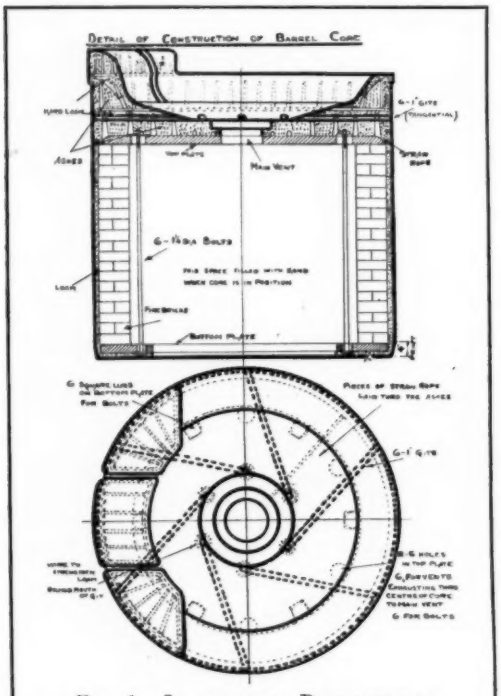


FIG. 1.—ILLUSTRATING DIFFICULTY OF RUNNING A CYLINDER DUE TO THE BARREL CORE BUCKLING.

upon the uncertain knowledge that certain iron and brick supports, and certain sand mixtures might have proved suitable for a similar type of casting in the past. That good castings are still being produced from such empirical data is remarkable, and speaks highly for the skill of moulders who are able to make these castings commercially. At the same time, very few managers or foremen will guarantee their castings, and their successive emergence from one foundry to another is very discouraging.

The cylinder under consideration was cast crown up. The first cylinder was lost through the barrel core buckling and a part of the crown breaking away. The diagram of the barrel core, Fig. 1, shows the difficulties of construction and of running the metal so as to prevent the breaking away of the upper portion of the core and of producing a clean, sound casting. In the second casting, ingates through the crown were made through the top of the barrel core as shown, in order that the metal on rising to the lower level of the crown would gently swirl on to the centre of the top of the barrel core, and the whole rise together. At the same time, it was realised that without an intimate knowledge and control of the properties of the loam used—strength, permeability to gas, shrinkage on drying and refractoriness—which must be such as to enable it to endure the flow and pressure of the molten metal, permit free escape of the gases generated and yield to the contracting metal, this procedure was risky, and the second casting would follow the first.

Similarly do these remarks apply to the *construction of the moulds and cores of all castings, for unless they can be prepared from day to day with a* CERTAIN ASSURANCE *that similar conditions are being reproduced, production of sound castings becomes an uncertain and harassing business.*

Fig. 7 represents photomicrograph of a locomotive cylinder taken from a section of the defective zone, proves the defect to consist of entrapped sand and oxide, suggesting that a portion of the mould or core was washed by the metal, and was trapped in this portion of the casting. Close examination of this and other cylinders presenting a similar defect, traced the origin of the defect to the collapse of a small core inserted in the lower portion of the mould which had been burned in drying.

Chaplets.—It is not uncommon for an otherwise good cylinder to be rejected on account of leaking at the chaplets or for the foundry to lose a casting because the chaplets gave way. Scientific design of chaplets, however, presents much the same difficulties as scientific control as a whole. The requirements of a chaplet are that it must (1) sustain a given load for a definite period of time, (2) fuse in the shortest possible time and form a perfect weld with the adjoining iron. The ideal design for strength is that which enables

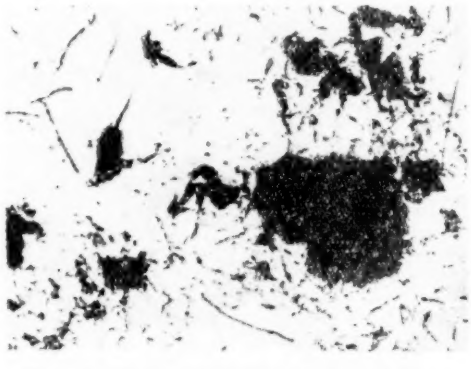


FIG. 7.—PHOTOMICROGRAPH TAKEN FROM THE DEFECTIVE ZONE OF THE STEAM CHEST OF A LOCOMOTIVE CYLINDER.

the chaplet to withstand direct compressive stress, when the entire load is concentrated on the central support, and a bending moment when the direction of the load does not coincide with the axis of the support.

Consideration of the relative value of the cylindrical, rectangular and corrugated supports leads to the conclusion that structurally a suitably designed corrugated support is the best, in that it gives the highest ultimate buckling strength, presents the greatest surface to the molten iron, and does not depend for strength on the efficiency of the joint between the support and top, which is particularly the case with the rectangular and circular supports.

Unfortunately the foundry does not possess suitable facilities for making its own chaplets, and whilst the designs at its disposal may be strong enough, the problem of obtaining a weld is left in the hands of the moulder. At the best this can never be more than a poor compromise, and the result is that the chaplet is often loosely attached to the casting. Photograph A, Fig. 8, shows a portion of a cylinder rejected because of trouble with chaplets. In this instance they could be pulled away from the casting with the hands.

The two principal objections to the common form of chaplets sold to-day are (1) that they are made in the same section of mild steel irrespective of whether for use in ¼- or 2½-in.

section, or whether they are for use at the top or bottom of the casting; and (2) that the central support for one particular section of casting may vary more than 20 per cent. in diameter. The foundryman endeavours to get over the difficulty of obtaining a weld by using his chaplets tinned or galvanised, or by treating with a mixture of red lead and turpentine. Evidence is still required to prove that these increase the fusion

FIG. 8A.—SHOWS A PORTION OF A CYLINDER REJECTED FROM CHAPLET TROUBLE.

between the chaplet and the casting, although we have proof to show that oxides or metals having low boiling points, are a prolific cause of blow-holes and spongy places.

Where a chaplet is necessary, the author uses the form shown by Fig. 8a. This does not differ radically from the standard chaplet sold, but is

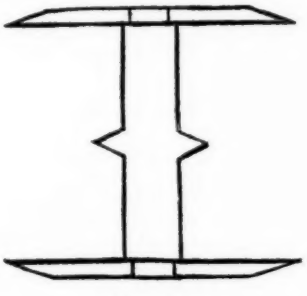


FIG. 8a.

modified to present easy fusion at the centre of the stem without reducing its strength, and also at the faces of the chaplet as an additional safeguard. Such chaplets thus enable a perfect weld to be produced whether used at the top or bottom of a casting. To remove any oxide and ensure a clean skin in use, these chaplets are pickled in

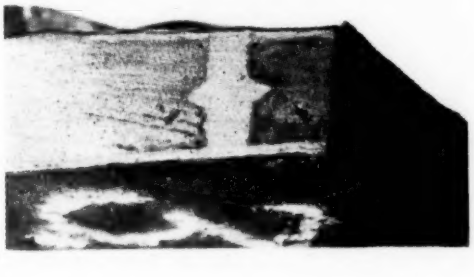


FIG. 8B.—SECTION THROUGH CHAPLET USED IN A LOCOMOTIVE CYLINDER.

acid and protected in store by means of oil. Photograph B, Fig. 8, shows a section through such a chaplet when used in a locomotive cylinder. Photomicrograph C, Fig. 8, shows the depth of carbon penetration and the efficiency of the weld between the edge of the chaplet and the cast iron.

Numerous instances of moulding defects may be cited, but they only go to demonstrate further the high importance of technical control of raw materials and of every operation in manufacture, if any measure of security against defective castings is to be guaranteed, and if cylinder losses are to be eliminated by any other method than the costly one of risking the casting. Apart from the commercial value of such a control in reducing scrap losses, cost of drying, etc., sand costs and its preparation are brought to an economical basis,

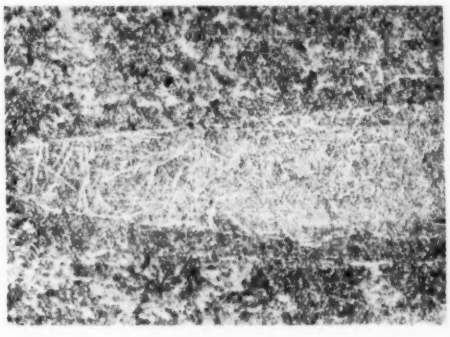


FIG. 8C.—ILLUSTRATING DEPTH OF CARBON PENETRATION AND EFFICIENCY OF WELD BETWEEN CHAPLETS AND CAST IRON.

whilst the reductions effected in handling charges, which represent a capital investment, are enormous. Some idea of the possibilities in this direction may be gathered from the fact that in the manufacture of 1 ton of castings under normal rule-of-thumb conditions, no less than 6 tons of sand may be used, which is often handled 8 times (incidentally a fertile field for the equipment engineer).

(To be continued.)

Wabana Iron Ore.

Wabana iron ore, which is mined at Bell Island, Conception Bay, on the East Coast of Newfoundland, though of comparatively recent exploitation, has already played some part in world politics. It has been extensively used by the Germans in place of the Minette ores, at a time when they preferred not to handle material controlled by the French. An intensive campaign has been opened by the European agents, Messrs. the British Empire Steel Products Company, Limited, of Scotia House, 110, St. Martin's Lane, London, W.C.2, to introduce the ore into Great Britain.

The progress which the mines have made and the influence it has wrought on the metallurgical industries of the world can be gauged by the fact that during the last few years no less than 1¼ million tons per annum have been shipped from the mines. The supply, however, is practically unlimited. Shipment which is made direct to any European port is restricted to eight months of the year from May to October, owing to the ice conditions surrounding the Newfoundland coast during the winter months.

The approximate analysis is 51.50 per cent. of iron as received; 11.50 per cent. of silica; 0.75 per cent. of phosphorus and 1.25 per cent. of moisture. The percentage of fines on recent shipments has varied from 15 to 20 per cent., but arrangements have been made to screen all ore shipped during the coming season, only the lump ore being shipped to European users, which will reduce the percentage of fines to a minimum.

THE ANNUAL MEETING of the Institution of Heating and Ventilating Engineers was held in London, when Mr. P. M. B. Grenville was elected president for the year. In his presidential address he suggested that the younger members should be included in the Council and on committees. Other suggestions for the future were the formation of provincial branches, and the institution of a bureau of information by a few experienced members to stimulate greater interest. Sir George Croydon Marks, M.P., also delivered an address.

XUM

Institute of British Foundrymen.

SHEFFIELD BRANCH.

Annual Dinner.

The annual Branch dinner took place at the King's Head Hotel on February 8, when Mr. John Shaw (Branch President) presided, and there was a large and representative attendance present, including the Lord Mayor of Sheffield and leading men in the industrial world.

Doles and Productive Work.

The loyal toast having been honoured, Mr. W. Clark (President of the Sheffield Chamber of Commerce) proposed "The City and Commerce of Sheffield." He said they could safely leave the city in the hands of the Town Council to make the centre of it a much better place than it was at present. Mr. Clark referred to the splendid work done by Sheffield University, which had grown and expanded until now it did not take second place to any University in this country or any other. With regard to industry he took an optimistic view, but there were "snags" on the road, and he hoped and trusted that they would not have their wheels spragged when they were moving on towards a better state of things than they had seen for a long time. The prices they had been having for their products were by no means profitable. The only hope they had was that prices would improve. Trade in 1923 was much better than it was in the previous year. They produced over seven million tons of iron and more steel, but Germany was organising her industries and was going to pay the 1914 rates of wages and was going to ask her men to work ten hours a day six days a week.

If the Government would do what it was arranged the late Government should do, we should be more contented; the necessity of placing at once the eight cruisers the late Government were pledged to place should be urged upon them. In the last two years Sheffield had spent two and a quarter millions of money over and above the normal in Poor Law doles. Would it not have been better if that sum had been spent on productive work. There was nothing so destructive to manhood as to receive parish relief. Everything they could do to urge upon the Government to put constructive work in hand they should do.

The Lord Mayor of Sheffield (Alderman A. J. Blanchard), in response, said he hoped the new Government would not take their policy and politics from America. The theories put forward at the Washington Conference were all right, but he still thought that the best way to prevent war was to be prepared for war. Sheffield was badly hit by doing away with the ordinary production of munitions without having to stand this extra blow of holding back the order for light cruisers. The Americans wanted to do a good many things for us, but he thought they had better set their own house in order. They had adopted Prohibition, but they could not enforce it in their own country. He had had complaints brought to his notice that in the trades represented at that gathering there was a certain amount of overtime going on. He could not think that was so, but he had promised to ask the manufacturers of the city to try to avoid overtime so as to absorb those who were out of work. The best thing to do under present circumstances was to produce the largest quantity of goods, and on the other hand to pay the best possible wages.

"The Visitors" was submitted by Mr. T. H. Firth (Past-President of the I.B.F.), who expressed the pleasure it was to see so many visitors and friends with them. He had received a letter from the President of the American Foundrymen's Association, thanking them for the manner in which they looked after the members of the deputation who came to Sheffield.

Mr. John Little responded.

"Kindred Associations" was proposed by Professor Desch, of Sheffield University, who said that the industry and science of metals and metal working had grown to such an extent that it was impossible for any one institution to deal with the entire industry. It would be a satisfactory thing if they could all belong to one institution which could cover all the industries. Those who had to teach the scientific side of this work were very much indebted to the industry, the leaders and men in which were very helpful to them; they were never turned away when they were able to give information.

Mr. W. G. Turner (President of the local section of the Institute of Metals) responded. There was always in Sheffield a thirst for knowledge, and it had produced very practical results. The great value of these societies was in the opportunity they offered to employers and employees, scientists and practical workers, for friendly foregathering and discussion of technical subjects in which they were interested.

A Key Industry.

In proposing "The Institute of British Foundrymen," Mr. C. K. Everitt said the craft of founding was one of the most ancient of all crafts. Right away down the ages they had been called upon to solve problems and difficulties. There was no industry but what was indebted and dependent upon the foundry. There was not one of our homes but was dependent upon the foundry; if they had no oven he did not know where they would be. They had had to take their share in the progress of humanity. The present day called for a great deal of technical knowledge and a great deal of scientific knowledge, and they in Sheffield were particularly fortunate in having such men as Professor Desch and his assistants at the University. There was in all of them a desire to attain the best. They had had troublous times, but they were winning through. He believed the world was in need of their products, and he wished they would pay them the price for their productions that would really be a fair price.

Grinding of Metals.

Mr. Oliver Stubbs (President of the I.B.F.), at the outset of his reply, said how much they owed to the President of the Sheffield Branch (Mr. John Shaw) who was undoubtedly one of the hardest-worked men in the Institute. Mr. Stubbs then referred to what had transpired the last few days with regard to the issuing from the Home Office of draft regulations for grinding and cleaning of metals in the workshops without having made any effort to approach the Institute of British Foundrymen. They were going to come into their town of Sheffield and ruin half of their trade by regulations which were unsuitable and not called for. They should, as an Institute, protest against any regulations drawn up for workshops without they had some say in the matter. How, he asked, could they get the trade of the country moving if they had to bear such regulations as these? They said that the men suffered from some particular form of lung disease in Sheffield. In making these examinations they had never taken into consideration the outside environment of these workmen. Many of them had not contracted the disease in the workshop. According to the regulations they had forty days only in which to put in their objections, and in this particular direction their Institute could do some good. Many of them had done very heavy and hard work in the Institute, but the old ones could not carry it on for ever. He should have liked to have seen a bigger percentage of younger members present that night. He asked every member to try and obtain new members for their Branch, as what they wanted was more members, particularly from the younger side. He had had something to do lately with the question of the securing of and training of apprentices for the foundry, and there was important work to be done in this particular direction. They could not reduce the wages they were paying to the workpeople—they were not enough—but they would have to increase the hours for work, otherwise they would be unable to cope with the keen competition. They must continue their efforts to bring about a better understanding between employer and employed and the less strikes they would have.

The History of the Manufacture of Cast Iron.*

By T. Makemson, Assoc. M.C.T., M.I.Brit.F.

Ancient Iron Workers.

The metal iron has been in use from the earliest times of which we have any knowledge. Some of the iron used by prehistoric man was undoubtedly of meteoric origin, but the metal was also extracted from iron ore in primitive furnaces. Iron is known to have been used in China 2,300 years before the Christian era, and it was used by the Egyptians and the Assyrians. The swords of Damascus acquired a world-wide reputation, and it is said that one of the Roman emperors possessed a sword factory in that city. The iron and steel of India were also celebrated in ancient times, and even up to the middle of the Eighteenth Century the best steel used in Europe was imported from India, where it was made by primitive native methods.

When the Romans came to this country, they found the ancient Britons in possession of implements and weapons of iron. The original inhabitants of this island appear to have been familiar with crude methods of extracting iron from its ores. They used bars of iron as currency, and a few years ago a deposit of such currency bars was discovered secreted in a manner which suggested that it was either the hoard of a miser or that the hole in which it was found was the strong room of the local bank.

The Romans themselves, with their usual enterprise, made considerable use of iron and steel in the manufacture of swords, shields and domestic articles, and during their occupation of this country they worked the extensive iron deposits of the Forest of Dean and Sussex. Their methods were primitive and wasteful, and a considerable amount of the iron passed into the slag or cinder. Huge heaps of this cinder have been found in the Forest of Dean, and from the sixteenth century onwards quantities of this material were smelted in the ironworks of the district in order to obtain the iron which it contained.

Ironmaking in the Middle Ages.

Little is known of the iron trade during the unsettled times of the Saxons; the trade appears to have flourished, however, until the arrival of the Normans, when a decline set in. As a result of diminished manufacture, iron articles became extremely valuable, and the kitchen utensils used in the Royal Household were classed among the Crown jewels.

The invention of gunpowder about the year 1310 created a demand for iron for the making of cannon. The earlier cannon were made of bronze, but iron was soon used extensively for the purpose. The gun tubes were made of bars of wrought iron arranged like the staves of a barrel, and held together with iron bands, and the projectiles were round stone balls known as "gunstones." From contemporary reports, it appears that these weapons executed almost as much damage among the gunners as among the enemy.

Up to this time cast iron was unknown, and the application of the metal was confined to such articles as could be forged; hence the use of wrought iron for making guns. The processes used for extracting the metal from the ore were of the crudest description; charcoal was the fuel, and the blast was usually supplied from a bellows worked by hand or foot. At the later period it became customary to drive the bellows by means of a water-wheel, and the works was usually placed near a running stream for this reason. By these methods it was impossible to obtain a temperature sufficiently high to melt the iron; reduction from the ore to the metal was therefore usually effected while the material was in a pasty condition; the soft mass of metal was then drawn out of the furnace, and after hammering to expel the slag, it was forged into the required shape. Both malleable iron and steel were made in these early furnaces. It was possible to exercise some control upon the final product by varying the proportion of fuel and ore, but usually the metal produced was of an uncertain character and lacked uniformity. Ironmaking in the Middle Ages was a domestic industry, and the iron manufacturer was often the local smith who made his own iron and then forged it into the required article. Although the methods of manufacture were so primitive, a surprising degree of skill was attained in craftsmanship, a proficiency which was probably due in part to Continental influence.

Discovery and Early Use of Cast Iron.

The discovery of cast iron took place on the Continent probably during the latter part of the fourteenth century. Previous to this time, cast iron had been frequently made as an accidental product when the temperature of the furnace became unusually high. Its value, however, was not understood, and it is related that, when cast iron was produced, the workman was fined for his inefficiency. In order to obtain a larger output of wrought iron, the practice arose on the Continent of building deep furnaces. One of the best known furnaces of this type was the German Stückofen, which is really the ancestor of the modern blast furnace. The production of cast iron naturally became more frequent, because the metal was in contact with the fuel for a longer period and higher temperatures were attained. Eventually it was seen that the accidentally-produced cast iron, so far from being an undesirable product, possessed properties of considerable value. The invention of the Stückofen, together with the discovery of cast iron, may be said to mark the real beginning of the iron industry.

The manufacture of cast iron in the blast furnace appears to have been introduced into this country in the latter part of the fifteenth century, and by the end of the century the term "iron-founder" was found fairly frequently. Sussex was the first district to adopt the new process, partly because at this time it was one of the principal iron producing centres of England and partly on account of its proximity to the Continent. Numbers of Continental workmen were from time to time brought over and were employed in the ironworks.

The principal castings made in the early foundries were cast-iron cannon. The moulds were generally swept up in loam, one of the oldest methods of moulding. By the end of the century, cannon weighing nearly three tons were quite commonly made. When one considers the primitive apparatus that the early founders must have used, the making of castings of this size was quite a creditable performance.

In addition to cannon, domestic articles and cooking utensils of various kinds were produced. Stoves for use in churches and houses also became important foundry products, particularly in Germany. Many of the later articles were built up of flat plates which were made in open sand by a method similar to that employed for making open-sand plates to-day. The ornamental designs which frequently adorned the stoves were made by pressing a die on to the level bed which had been made by strickling. When the ornament was required to be duplicated on the one plate, the die was simply pressed into the sand at several places until the ornamentation was complete. As production increased, it became more usual to employ patterns with the ornament already fixed in place.

Early Use of Coke.

After the introduction of cast iron the English iron industry grew rapidly. The essential requirements were iron ore, timber for conversion into charcoal to be used as fuel, and skilled labour. In several parts of the country, notably Sussex and the Forest of Dean, both ore and timber were plentiful, and these localities naturally became the ironworking districts. The destruction of the woods in order to provide fuel soon became a serious matter. Timber was required for building

* A Paper read before the Burnley Section of the Institute of British Foundrymen, Mr. Hartley presiding.

purposes, and also for shipbuilding, for, by the time of Queen Elizabeth, England had become an important maritime nation. In the first year of the reign of that monarch an Act of Parliament was passed which limited the cutting of timber for use as fuel in ironworks. Breach of the Act was punished by the infliction of heavy penalties. In 1593 there was passed a further Act which increased the restrictions on the use of fuel and entirely prohibited the erection of new ironworks.

These measures were probably necessary in order to preserve the timber for what were then considered to be more important purposes, but they had a disastrous effect upon the struggling iron trade. At the date of the passing of the latter Act referred to, the annual production of iron in England was 180,000 tons; less than 60 years later it had fallen to 17,300 tons, owing to the scarcity of charcoal fuel and the consequent shutting down of the furnaces.

Several attempts were made to substitute coal in place of charcoal. The best known of those engaged in this work was the celebrated Dud Dudley, who was the son of the then Earl of Dudley. The Earl appears to have worked some of the iron deposits on his estate, and his son entered upon the management of his father's works immediately he left Oxford in 1419. He commenced his series of experiments on the use of coal as a furnace fuel, and eventually he announced that he was able to use "pit coale" for iron smelting after submitting it to a process which he described as "cooking" it; in other words, he converted the coal into coke. Unfortunately, Dudley's invention was put to little practical use. He was violently and unscrupulously opposed by the charcoal ironmasters, who feared the rival process and therefore shortsightedly attempted to discredit it instead of endeavouring to co-operate. He was ousted from his works at Pesneth Chase, in Worcestershire; he then recommenced operations at Himley, in Staffordshire, but, as he possessed no forge, his only available customers were his rivals, who took every opportunity to disparage his iron. He was eventually ejected from these works, probably by some legal squabble; he then erected other works, which were damaged in a riot. He was afterwards imprisoned for debt, and was further handicapped by unsuccessful business undertakings in Bristol. During the Civil War he superintended the making of cast-iron cannon for the Royalist troops, and he became Colonel in the Royalist army. He suffered further losses during the war, and eventually he retired from his turbulent career in the iron trade. His experiments and vicissitudes are described in his book, "Metallum Martis."

In addition to manufacturing iron for forgings, Dudley was also an iron founder. Not only did he make the cast-iron cannon already referred to, but he states in his book: "I also made all sorts of cast-iron wares, as brewing cysterns, pots, morters, and better and cheaper than any yet were made in these nations with charcoles."

The Darbys and Coalbrook Dale.

Nearly one hundred years after Dudley's retirement a scheme for using coal as fuel was put into successful operation by a member of the Darby family, who were for so long associated with the famous Coalbrookdale works in Shropshire. The first Abraham Darby, who originally hailed from Birmingham, was a malt maker at Bristol. With the aid of some Dutch workmen, he operated a small brass foundry at Baptist Mills, Bristol. To the brass foundry business he added the making of iron castings, not, however, until after much experimental work, in which he was assisted by a Welsh boy named Thomas, who had come to Bristol in search of employment. The process which Darby and Thomas evolved was operated in secret in works owned by the Darbys for more than one hundred years.

Darby eventually disagreed with his partners, who became alarmed at the probable financial loss which they anticipated would result from his innovations; he then took a lease of the Coalbrookdale Works, whither he was accompanied by Thomas. Darby died in 1717, at the age of 40, and after some years the management passed into the hands of his son, another Abraham Darby. Young Darby saw that the success and perhaps the very existence of the iron trade depended upon the provision of a plentiful supply of some fuel other than charcoal. He experimented with a mixture of charcoal and raw coal, but, as this was not successful, he followed Dudley's plan of converting the coal into coke, and after a continuous trial extending over six days and nights, he achieved satisfactory results. By reason of the advantages which were derived from the adoption of the process, coupled with Darby's energy and enterprise, the Coalbrookdale business flourished, the works were considerably extended, and in 1764 another works was erected at Horsehay, a few miles away.

Among other innovations introduced by Darby were the employment of atmospheric engines or "fire engines" for working the bellows, which had previously been worked by a 24-ft. waterwheel, and the construction of an iron tramline between his two works. After the death of the second Abraham Darby, the management of the works passed into the hands of his son, who was also called Abraham, and, upon his death, his nephew Edmund took control. The same enterprising spirit existed. The third Abraham was responsible for erecting the first cast-iron bridge which was erected over the River Severn, while Edmund rebuilt the Horsehay Works, and, recognising very early the value of the new steam engines of Boulton and Watt, substituted them in place of the "fire engines."

The successful use of coke by the second Abraham Darby marked the beginning of a new era in the iron trade, and the modern iron industry may be said to have commenced at this time. Vast quantities of fuel became available, new ironworks were built, and old ones were re-opened. It is noteworthy that from this time the location of ironworks gradually changed from localities where wood was plentiful to districts adjoining the coalfields.

Another works which was famous in the eighteenth century was the famous Carron Ironworks in Scotland. At this works were made cast-iron guns, including the well-known "Carronades" and also domestic articles, a branch of business which is still continued by this famous company at the present day. The Carron Works was founded by Dr. Roebuck in 1759. Roebuck was a very ingenious and enterprising man, and many of his brilliant ideas were put into practical shape by his friend Smeaton, who afterwards built the Eddystone lighthouse. Among the improvements effected at the works and attributed to Smeaton was the replacement of the bellows by a reciprocating blowing apparatus.

Iron and the Growth of Engineering.

Side by side with these developments in smelting and casting, improvements were introduced into the manufacture of wrought iron, which, with the exception of carbon steel, was the only other form of ferrous metal in general use. In 1783 James Cort introduced the method of rolling wrought iron into bars instead of the wasteful, laborious and inaccurate method of hammering which had been employed up to this time. In the following year he introduced the process with which his name is most frequently associated; this was the making of wrought iron by "puddling" in a reverberatory furnace where the metal was not in direct contact with the fuel. This invention enabled coal to be used in place of charcoal, and made possible considerable economies in production. Cort, who was a native of Lancaster, reaped little pecuniary benefit from his invention. His partner proved to be dishonest, and other manufacturers took advantage of his misfortunes and infringed his patents. He lived in poverty for several years, but a few years before his death he was granted a pension of £200 per annum by the Lords of the Treasury.

Up to the latter part of the eighteenth century the principal use for iron was in the manufacture of domestic articles and ordnance. To-day we associate iron most frequently with the engineering industry, but at that time engineering was just coming into existence. Machinery was used to some extent in collieries and mines, but wood and non-ferrous metals were extensively employed

in machine construction. Galloway* desbribes a colliery pumping engine which had a brass cylinder, a copper boiler with a lead top, wooden pumps and a brass working barrel.

The extensive employment of the atmospheric engine, the invention of the steam engine, and later of the locomotive, each in turn created an increased demand for iron. The Industrial Revolution which followed the invention of the steam engine, and which was marked by the introduction of machinery into many manufacturing processes, created further demands for the metal, and at the same time progress in mechanical science and invention was responsible for the development of ironworks plant and for increased output.

The Wilkinsons.

An outstanding figure in the iron trade at the end of the eighteenth century, and one to whom too little credit has been given, was John Wilkinson, the Staffordshire ironmaster. He was the son of Isaac Wilkinson, a native of Wrexham, who settled in the Furness district of Lancashire in 1740, after spending a short period in Cumberland, during which time John was born. After being employed in an ironworks as a workman, Wilkinson senior became proprietor of a small ironworks at Wilson House, near Ulverston, and manufactured domestic irons. During the following few years he took out several patents in connection with improved methods. The most interesting of these patents to foundrymen was granted in 1758, and related to a method of making cast-iron cannon, pipes, cylinders, and other articles.

From the specification, the process appears to have been similar to the method employed for making similar articles at the present day. The mould was made in dry sand in a moulding box, and after stoving it was given a coat of charcoal or plumbago blacking. The core, or "cord" as it is called, was made on a perforated iron core barrel covered with straw or hay rope and loam. The larger cores were built of brick in the manner of present-day loam cores.

Isaac Wilkinson later removed to another works at Bersham, near Wrexham, but despite his enterprise and ingenuity, his business does not appear to have been commercially successful. His more famous son, John, left his Lancashire home at the age of 20 and found employment in the ironworks of South Staffordshire. He designed and constructed a blast furnace, and later he established himself as an ironmaster. A few years later he joined his father at the Wrexham works and eventually he took over its entire management. John Wilkinson became interested in other ventures in the iron trade, his business connections extended rapidly, and eventually he became one of the foremost ironmasters of the day. He was one of first to adopt Darby's method of substituting coke in place of charcoal, and he constructed the cylinder-boring plant which enabled Watt to make a practical success of the steam engine, and he also manufactured wrought iron at a new forge which he built at Broseley, near Bridgenorth.

Wilkinson's progressive policy is shown by his readiness to instal new machinery and to conceive and adopt new and unconventional methods. The first engine constructed by Watt at his Soho works was ordered by Wilkinson to work the bellows at Broseley, and he was one of the first manufacturers to use the tilt hammer which Watt invented. He built iron boats for transporting his castings down the River Severn, he constructed an ingenious threshing machine, and he is credited with having erected the first large steam engine in France. His enterprises embraced all branches of the iron industry, and at one of his newer works at Bradley, Staffordshire, he manufactured tubes.

Like his father, John Wilkinson was original and courageous, but unlike his father, he was uniformly successful in business and left a large fortune, most of which, however, was squandered in litigation by his sons and nephews. His younger brother became an ironmaster in France, and his sister married Dr. Priestley, the discoverer of oxygen.

Wilkinson was a man of strong, tempestuous, and eccentric character. His faith in cast iron showed itself in many unexpected directions. At Bilston he constructed a cast-iron chapel and provided it with a cast-iron pulpit. He died in 1808, and after two temporary interments he was buried in his own garden in a cast-iron coffin which he had made some years before, and over the grave a cast-iron tombstone was erected. Some years afterwards his body was again disinterred, and he was buried for the last time at Lindale-in-Furness, near the scene of his early labours.

The Scottish Iron Industry. Use of Hot Blast.

The growing popularity of the steam engine and the increase in the use of machinery of all kinds caused a rapid increase in the demand for iron and was responsible for the exploitation of many hitherto unworked deposits of iron ore. As early as 1801 David Mushet pointed out the value of black band ironstone, which is found so plentifully in the Clyde Valley. Up to this time the ore was considered of little value, and Mushet encountered considerable opposition in his efforts to induce furnace owners to use what was contemptuously described as "wild coal." The use of hot blast, which was introduced a few years later, was found to facilitate the smelting of this kind of ore and its use soon became general. So plentiful was the supply of what was now seen to be valuable material, that many new furnaces were built and the Scottish iron industry rapidly grew to be of considerable importance.

Neilson, who was the inventor of the use of hot blast, was the superintendent of the Glasgow gas works, and had formerly been a colliery engine-wright. Up to the time of his invention the air was blown into the furnace as cold as possible. After being consulted with regard to a furnace which was working irregularly, Neilson carried out an investigation on the combustion of gas in hot air, and concluded that if the blast were preheated more efficient working and greater economy in fuel would be obtained. After encountering much opposition and prejudice from different ironmasters, he was allowed to try out his scheme at the Clyde Ironworks, but he was limited to temperatures not exceeding 80 deg. C. The results were encouraging, but it was some years before he was permitted to experiment at higher temperatures. When he did so the plan was so successful that it was soon put into operation in most of the Scottish ironworks, and a few years later the practice became general throughout the trade except in a few works making special close-grained iron.

Neilson employed a small coal-fired heating apparatus. In 1845 J. P. Budd patented a method of using the waste gases from the blast furnace for heating the blast, and this more economical method gradually became general.

The Use of Iron in Engineering Construction.

It is instructive to trace the manner in which the extended use of iron contributed to mechanical progress, and how at the same time iron-manufacturing processes were helped by the progress of mechanical invention. The experiments of William Fairbairn, of Manchester, directed attention to the possibility of using iron as a shipbuilding material, although earlier isolated instances of such use of iron are on record, notably the iron boats of John Wilkinson already referred to. Fairbairn constructed a vessel of iron plate in 1831, and in 1836 he opened a shipbuilding yard at Millwall at which he built a number of vessels within the next few years. The introduction of iron as a shipbuilding material marked the commencement of the construction of vessels of much larger size than the wooden vessels which had previously been built.

The increased manufacture of forgings of a larger size than could be treated by hand hammers or by tilt hammers led to the invention of the steam hammer in 1837 by Nasmyth, another Manchester engineer. Nasmyth did not make use of his design for some time; it was only after he unexpectedly discovered that a similar hammer made from his own design had been constructed and was in successful operation at Le Creusot that he patented his invention and turned it to practical account.

* "Annals of Coal Mining," Vol. I, p. 303.

XUM

During the early days of engineering cast iron was frequently used for purposes for which wrought iron would have been more suitable. Cast-iron rails were used for the early railways; they were, however, soon superseded by rails of wrought iron, and many years later wrought iron gave place to mild steel for this purpose. Cast-iron bridges were quite common during the early railway period, and many of these bridges exist to-day. Wrought iron was later found to be a more suitable material on account of its greater tenacity and ductility. In more recent years, wrought iron as a structural material has been almost superseded by mild steel, which is even more suitable for this purpose. Perhaps one of the most striking examples of faith in cast iron was afforded by Mr. Blackett, one of the early locomotive experimenters, who provided his first locomotive with a cast-iron boiler. It is scarcely surprising to find that she "blew all to pieces" at the first trial.

As engineers became more experienced, it was seen that both cast iron and wrought iron had their own individual fields of application, and the various purposes for which each was most suitable became defined. Before the middle of the nineteenth century the Iron Age had really arrived. Engines of iron traversed the country on iron rails, overseas transport was effected in iron ships, machinery had rapidly come into use for every manufacturing purpose, and to meet the rapidly-increasing demand for the metal, new ironstone fields were opened up and newer and larger furnaces were erected.

The Evolution of the Blast Furnace.

In general, it is correct to state that by about 1830 the methods of manufacturing pig-iron had been evolved and established on lines which in principle are similar to those which are followed at the present day. The modern ironworks is vastly different from the works of that period, but the changes which have taken place in the interval have been mainly improvements in manufacturing methods, directed towards obtaining increased production and more economical working, rather than changes in fundamental principles.

In the early part of the nineteenth century the furnaces were built of masonry and at the outside were square in section. The interior was of circular section with the exception of the hearth, which was usually square. The furnaces were frequently built on the side of a hill in order that the material could conveniently be taken to the top, as lifts were not then in use. The output did not usually exceed 40 tons per week. The introduction of hot blast directed attention to improving the design and working of the furnaces, and much progress was made in this direction, particularly in Staffordshire. An improved furnace erected in 1832 in that county had an output of 115 tons per week. The shape of this furnace differed materially from that of existing furnaces in several particulars, the most noticeable alteration being the shape of the hearth, which was circular. These improvements in design were carried further in other furnaces of larger capacity which were subsequently erected, and in 1854 it is said that a production of 300 tons per week per furnace was frequently obtained.

Reference has already been made to the use of waste gases for preheating the blast. The utilisation of the gas necessitated the closing of the furnace at the top, an object which was afterwards achieved by the use of the now well-known cup and cone arrangement. Blast-furnace gas was later used as a fuel in boilers used for steam-raising. The exploitation of the vast iron-ore deposits of North Yorkshire was begun in 1836, and a few years later Cleveland had become one of the foremost iron-producing areas in the world. Many of the furnaces constructed in Cleveland were of large capacity, and a weekly output of 400 or even 500 tons per week was not unknown. The preheating of the blast in stoves of the Cowper type instead of passing it through heated cast-iron pipes also originated in Cleveland. Larger furnaces necessitated the provision of improved auxiliary machinery: lifts were introduced for the purpose of taking the materials to the top of the furnace, and improved blowing engines capable of producing higher blast pressures took the place of the older beam engines.

In the United States the manufacture of pig-iron grew rapidly during the latter part of the nineteenth century. Blast furnaces of increasingly large size were constructed, and the speed of working was accelerated. In 1890 a furnace in Michigan attained the hitherto unthought of output of 2,500 tons per week. The rapid driving and large output which is now characteristic of American furnaces has materially influenced blast-furnace practice and design in other parts of the world, including our own country.

In the blast-furnace plants which have been erected during the present century, mechanical and electrical inventions play important parts. Lifts are now being superseded by automatic charging apparatus. Magnets for transporting pig-iron, mechanical pig breakers, pyrometric control of temperatures, the more efficient cleaning and utilisation of furnace gases, the utilisation of slag and the use of the turbo-blowers in place of the reciprocating blowing engine are some of the improvements which are gradually becoming general practice in all parts of the world. The highly-organised modern ironworks is vastly different from the simple furnace of a century ago, yet the principles of iron smelting which were established by the early pioneers are almost identical with the underlying principles practised in the modern works to-day.

The Evolution of the Foundry.

Several references have been made to the evolution of iron founding as distinct from iron manufacture; it is interesting, however, to pursue the subject somewhat further.

For many centuries castings were made with metal obtained direct from the furnace in which it was smelted from the ore. The remelting of the iron in the cupola is said to have been first practised by Reaumur, the inventor of malleable castings, who constructed a small portable cupola about the year 1750. In 1794 John Wilkinson invented a cupola which in principle is not unlike that of the furnace in use at the present day. The change from castings of "direct" metal to cupola-melted castings was gradual, and even to-day large quantities of "direct" metal castings are produced. The gradual adoption of cupola melting may be said to mark the inception of iron founding as a separate industry distinct from iron manufacture.

An early type of cupola which was used extensively was rectangular in section and was built up of cast-iron plates lined with rectangular firebricks. It is interesting to note that James Watt melted mixtures containing steel scrap, thus anticipating the modern use of "semi-steel."

The actual moulding processes of to-day are probably little different in principle from those that have been practised for generations. Before the discovery of cast iron, castings were made of bronze or of some other non-ferrous alloy. Loam moulding or some allied process was the method of moulding usually employed, and loam moulding continued to be the usual process after the introduction of iron castings. Where loam moulding was not applicable, green sand was invariably adopted. The patent specification of Isaac Wilkinson already referred to is one of the earliest records of dry-sand moulding. Dry sand does not appear to have been commonly adopted for large work until one hundred years later, when John Surtees, who managed the foundries of Robert Stevenson & Company, of Newcastle, created something of a revolution in the North East Coast district by making large engine cylinders in dry sand. This method was found to be more economical than loam moulding, and it was soon adopted in other parts of the country. The John Surtees prize, which is controlled by the Newcastle and Scottish Branches of this Institute, is a memorial to the work of this pioneer.

The modern changes in moulding practice have been concerned on the one hand with the making of increasingly larger and more complicated castings, and on the other hand with the production of large quantities of castings from the same pattern. Apart from the possession of adequate lifting and transport facilities, the former develop-

ment has been made possible by the skill, experience and judgment of the individual foundryman. Quantity production of castings began with plate moulding, and at the present time is undergoing rapid development owing to the ever-increasing employment of moulding machinery.

Conclusion.

Space does not permit of more than a passing reference to the part which has been taken by the study of metallurgical science in the building up of the iron industry. In spite of the many inventions which have been referred to, progress would have been much slower without the advances which have been made in metallurgy. The contribution of modern science to the manufacture of iron is considerable and is probably of even greater importance in the manufacture of steel. During recent years the necessity for scientific control in the foundry has been realised, and most modern foundries are now operated and conducted upon much more systematic and scientific lines than they were some fifteen or even ten years ago.

In a brief account such as this, attention is naturally directed to the outstanding personalities: it must not be forgotten, however, that the iron industry owes much to the large number of lesser-known men whose labours have been directed towards the same end. These men, by their foresight, courage and energy, have assisted in the progress of the iron trade, and have therefore contributed materially to the welfare of mankind.

The author wishes to thank the Metropolitan Vickers Electrical Company for assistance, and his old teacher, Mr. E. L. Rhead, and Mr. J. S. G. Primrose for the loan of slides.

Chemical Aspects of Welding.

In a Paper on this subject read at a meeting of the Institution of Welding Engineers, London, on Tuesday, MR. J. R. BOOER said that the principle which governed nearly all the reactions involved in welding was the principle of oxidation and reduction, and it was much to be regretted that many welders referred indiscriminately to "oxide," "deoxidising" and "carburisation" without comprehending the true significance of these terms, and without understanding their mutual relationship. Discussing familiar oxides and other metals, the author said that the difficulty in the welding of nickel was that the molten metal readily occluded CO and other gases, which caused it to swell up and become spongy. A patent had been taken out for the welding of nickel in the presence of carbon or a carbonaceous material. The true welding of aluminium was impossible without the use of a suitable flux, to remove or prevent the formation of oxide.

The prevention of oxide formation was approached from two distinct directions—chemical and physical. The chemical method made use of suitable reducing agents which decomposed any oxide formed, and the physical or protective method (1) protected the welding rod, (2) protected the deposited metal, and (3) dissolved any undecomposed oxide. The reducing agent might be added to a flux or be incorporated in the welding wire or rod, but in the latter case the use of a suitable flux was still essential to prevent local oxidation. A large variety of reducing agents had been used with varying degrees of success. One of the least successful, though still in extensive use, was carbon, the reducing action of which at the temperature of the welding operation was extremely small. Added carbon was also inefficient in replacing carbon removed by oxidation, as for example in the welding of cast iron. Silicon was not a reducing agent in the proper sense of the word. The properties of ferro-silicon were similar to those of silicon. Calcium silicide, however, possessed definite and powerful reducing properties on account of the presence of the element. Further, if calcium silicide was decomposed, the silicon obtained was the yellow amorphous variety which was readily oxidised. The final product, when calcium silicide was used for reduction, was calcium silicate, which possessed valuable slagging properties. Aluminium was one of the most powerful reducing agents obtainable and, if properly protected, gave very satisfactory results. Another highly successful reducing agent was titanium, which had been used as a scavenger with much success in the steel industry, and was equally efficient in welding. Phosphorus had a limited use as a reducing agent in welding. It was very efficient, but should be used with great caution, as it formed stable phosphides with most of the metals, and if present in excess of the requisite amount would bring about the separation of the phosphorus eutectic, which weakened a weld.

Slag formation and the chemical properties of welding slags was a subject of the greatest complexity, but a very necessary subject for manufacture of fluxes. The earliest flux in history was the sand used in smith's welding, in which case a complex iron silicate was formed. This silicate, however, decomposed below the melting point of iron, and therefore sand alone was unsuitable as a welding flux. The silica slags, however, were of great value in welding, and fell into three classes—(1) soda-silica, (2) magnesium-silica and 3) soda-calcium silica slags. All these dissolved Fe_3O_4 readily, the soda-silicate variety being the most active in this respect.

Welding cast iron by the electric arc could not yet be described as wholly satisfactory owing to the variation in physical properties frequently met. At present welding with a graphite electrode gave good results, but there was scope for a great deal of investigation in this direction, and this was at present being undertaken. Welding cast iron by the oxy-acetylene process, however, could be carried out to perfection. Welding mild steel with the electric arc was extremely successful, but in any case a protective flux should be used. Mild steel could be welded with equal success by the oxy-acetylene process, but the problem of eliminating oxide when welding iron and steel was a very difficult one, and had received considerable attention for many years. It had been shown that its reduction by the flame of the blow-pipe was not possible, and it was therefore necessary to fall back on some form of reducing agent. It had been found that a deoxidising material in the form of a liquid gave excellent results when welding steel. One product on the market was specially prepared for use with welding wire, which did not contain deoxidising elements. It was recommended for use in repair work, for welding sheet metal—especially thick material—and castings. At the high temperature of the flame it slagged the oxide, maintained the surfaces clean and prevented inclusion of oxides. It thus facilitated the rapid execution of the weld and, in consequence, reduced to a minimum the overheating effects and thus eliminated local defects. Medium and hard steels required careful handling, but indifferent results were obtained because of the metallurgical phenomena which intervened. A flux similar to that used for cast iron should be employed. Provided oxidation was prevented by the use of a flux, the measure of success of the operation depended on the right heat and mechanical treatments being applied.

Obituary.

MR. HENRY IVOR COE, lecturer in metallurgy at the University College, Swansea, died recently.

MR. W. PARTRIDGE, nail and chain manufacturer, Cox's Lane, Old Hill, died recently, in his 75th year.

MR. JAMES DICKIE, who had been manager of Palmers Shipbuilding & Iron Company, Limited, Jarrow, for about 40 years, has died. Mr. Dickie, who was 77 years of age, began his career as a workman on the Clyde, and assisted to construct wooden vessels. Later he was appointed superintendent of Nelson, Donkin & Company, who owned a large fleet of vessels, and ultimately became a well-known figure in N.E. Coast shipbuilding and ship-repairing circles.

Indian Steel Tariff.—While the Indian Tariff Board have hardly begun drafting their report, fifteen members of the Indian Legislative Assembly have tabled a resolution urging the Government to obtain an *interim* report from the Board, to place before the Assembly proposals for the protection of steel, in time for the coming Budget.

XUM

Modern Automobile Foundry Practice.*

By P. Pritchard.

The casting of metals, or as it is more commonly called founding, is one of the oldest (if not the oldest) branches of the engineering industry. In spite of this, however, less progress had been made in this particular art up to ten years ago than in any other branch of engineering; indeed, it has long been a common expression to say that the foundry was the "Cinderella" of the engineering trade; it is pleasing to record, however, that more progress has been made in the foundry trade during the last twenty years than had been accomplished in any previous century or more.

There is no doubt that it is the development of the modern internal-combustion engine which has been to a large degree responsible for this progress. Further, it will be admitted readily by those acquainted with the facts that the recent war and the consequent demands necessitated by it upon the foundry trade have been the means of bringing modern foundry practice along at such a rapid rate in the past few years. Twenty years ago the average foundry was the most neglected portion of the works, and usually run by rule-of-thumb methods. To-day the foundry trade is receiving the closest attention from those responsible for a firm's productions. Scientific control, combined with laboratory research and technical investigation, have replaced the old rule-of-thumb methods, until to-day the foundry is taking its proper place amongst the more important departments of an engineering works.

Underlying Principles.

The broad principle underlying all foundry practice consists in the preparation of a mould or receptacle, formed to a desired shape, and made of some material sufficiently refractory to resist the action of the molten metal which is poured into it, *i.e.*, speaking very broadly, the whole art of the founder is concentrated upon preparing (1) a satisfactory receptacle for molten metal to give the desired shape, and (2) to ensure that the metal used will give a homogeneous casting. These receptacles or moulds, as they are termed, may be divided into two classes—(*a*) the temporary mould, (*b*) the permanent mould; generally speaking, these are the two great distinctions of foundry practice, though it is true that they are capable of being further sub-divided.

Taking first the destructible mould, the material used in the preparation of this is most commonly sand, containing a high percentage of silica with sufficient binding matter (generally in the form of alumina) to give it a certain amount of plasticity. Whilst this type of mould is sufficiently refractory to withstand the heat of the metal, it is extremely susceptible to breakage or any form of abrasion, and consequently can only be used once, as the taking of the completed casting from the mould destroys it entirely. On the other hand, the permanent mould is generally made of iron or steel, and whilst it is obvious that this type of mould can only be used to cast metals which have a considerably lower melting point than the metal composing it, the mould is, comparatively speaking, indestructible, and will last long enough for many hundreds or even thousands of castings to be made from it.

Sand Moulds.

Dealing first with the question of making castings with sand moulds, the primary essential is—patterns. For a simple solid casting this is an exact replica of the shape of the article desired to be made as a casting, excepting that it is made slightly larger in order to allow for the contraction which takes place in the metal during cooling. Secondly, although the casting may be desired in one piece, it may be necessary for the pattern to be made in two, three or even more pieces in order that it may be withdrawn from the sand without damaging the mould. Fig. 1 gives an indication of the method used in making the mould for a simple flywheel casting. It will be observed that the mould is made in two parts, the reason for this being that if the sand is rammed around the pattern in one solid piece, it would be impossible to withdraw this from the sand without breaking the mould away. The mould is therefore made in two parts, and when the "ramming up" (*i.e.*, the tucking of the sand around the pattern) is completed, the two halves of the mould are separated across the joint line indicated, after which the pattern can be withdrawn from the sand without

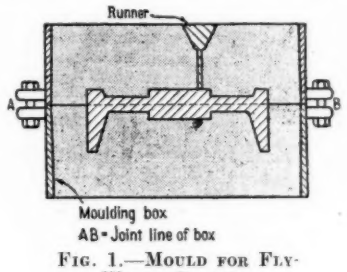


FIG. 1.—MOULD FOR FLY-WHEEL CASTING.

disturbing it. Two boxes made of iron, open top and bottom, and fitted with locating pins, are used to contain the sand. When the pattern has been withdrawn, the two halves of the mould are once more closed together and the metal is poured into the mould through the runner indicated. As soon as the metal is sufficiently set, the sand is broken away, leaving the casting exposed, which is then taken along to the fettling shop, for any adhering sand to be cleaned off and the metal composing the runner removed.

The process described above forms the basis of all moulding practice in sand, and whilst it is capable of an infinite amount of elaboration, the underlying principle is always the same. When it is desired to produce a hollow casting, such as a piston, the procedure is exactly as above, with the exception that an additional part is required. This is known as the core. The core is formed in sand from a separate model or pattern, known as the corebox, which is made to the exact shape of the interior portion of the casting required. The corebox is filled with sand, rammed into every

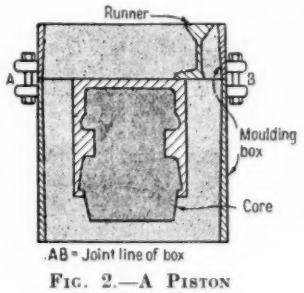


FIG. 2.—A PISTON MOULD ILLUSTRATING CORED WORK.

portion of the box. The corebox is made in two, three or more portions as may be required in order to take it apart without breaking the core in any way. As soon as the core is withdrawn from the box, it is taken into a stove or core oven and baked until all the volatile matter in the sand has evaporated. This leaves the core fairly hard and makes it capable of being handled without breakage. The core is placed in the bottom half of the mould, as indicated in Fig. 2, the top half of the mould is then placed in position, and the metal poured in. The remainder of the procedure is as described above.

* A Paper presented to several branches of the Institution of Automobile Engineers. Mr. Pritchard is a director of the Midland Motors Cinders, Limited, and is also connected with the Birmingham Aluminium Company, and the Pneulec Machine Company.

Moulding Machines.

The moulds and cores for automobile castings, when the quantities warrant it, are often made on machines. When the mould for a casting is made on a machine, it is necessary for the different parts of the pattern to be secured to a pattern-plate made either of wood or metal, which is provided with pins to locate the position of the moulding boxes. The moulding boxes must, of course, be drilled to jig and interchangeable. All the various parts of the patterns are accurately located on the plates in such a manner that when the different parts of the mould off the pattern-plates are assembled, they will all match up. Moulding machines can be divided roughly into three classes: (1) Machines which withdraw the pattern; (2) machines which ram the sand into the mould or corebox; and (3) machines which combine both

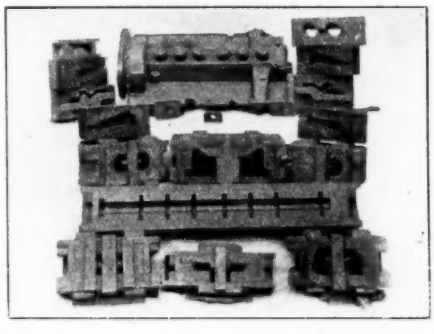


FIG. 3.—SHOWS THE NECESSARY PATTERNS AND CORE BOXES REQUIRED TO PRODUCE A 6-CYLINDER CRANK CASE.

operations and ram the sand and withdraw the pattern.

The chief advantage of the first-mentioned type of machine is that it enables the pattern to be withdrawn from the sand without damaging the mould, and also assists the moulder to produce more uniform castings, owing to the fact that the pattern is not "rapped" excessively, an operation which would cause the mould to become larger than the pattern and consequently make the casting larger and heavier than intended.

The second class of machine eliminates much of the hard work necessary to ram the sand around the pattern by hand. When it is realised that, in making, say, an average 4-cylinder crank-case, up to half a ton of sand has to be rammed into the mould and cores, the saving in effort is obvious. Many different methods are used for ramming the sand. In one type of machine the sand is squeezed into the moulding box either by

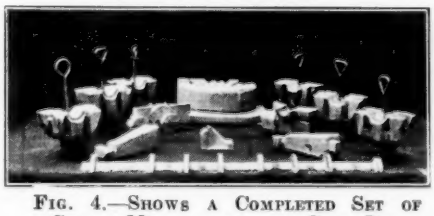


FIG. 4.—SHOWS A COMPLETED SET OF CORES MADE FROM THE CORE BOXES SHOWN IN FIG. 3, READY FOR ASSEMBLING IN THE MOULDS.

hydraulic power or compressed air. In another type the sand is thrown into the box with great velocity by means of an impeller or paddle driven at a very high speed. The sand is conveyed from a hopper by means of a conveying belt, and thus a continuous stream of sand is projected into the moulding box. Another, and perhaps the most widely used, principle is the jolt-ram method. The principle employed in the jolt- or jar-ram machine consists in raising the table carrying the pattern and moulding box (loosely filled with sand) for a short distance and then allowing it to fall suddenly upon an anvil. The abrupt stoppage of the descent, together with the resultant jar, causes the sand to pack more tightly into the box. This operation is repeated rapidly (from 150 to 250 blows per minute), and in an astonishingly short time the whole of the sand is tightly packed into the box. Of course, as the sand packs down into the box, more is added until the box is slightly over full with hard-rammed sand. The surplus is strickled off, and the mould is then ready for the pattern to be withdrawn. In some cases, instead of adding sand whilst the jolting is proceeding, a loose wooden frame is placed on the moulding box in order to deepen it temporarily, and the sand filled in to the top of the frame. This supplies the extra sand required to fill the mould completely when rammed tightly. After completion of jolting the frame is removed, and any surplus sand strickled off as before.

The third class of machines is, of course, simply the ramming machine described above with additional attachments for withdrawing the pattern.

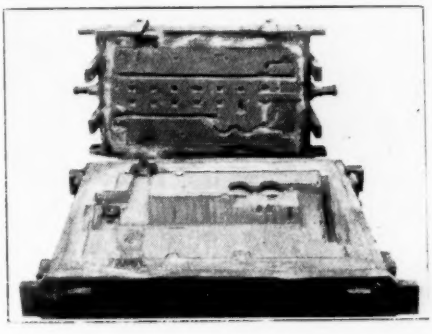


FIG. 5.—SHOWS THE MOULD WITH THE PATTERN WITHDRAWN AND FACED WITH FRENCH CHALK.

As soon as the ramming of the mould is completed, the pattern-plate to which the pattern and moulding box are located is vibrated or rapped, and the box is either lifted upwards away from the pattern by the mechanically-operated pattern-drawing attachment or, alternatively, the moulding box remains stationary and the pattern and pattern-plate drop away from it. The mould is then ready for lifting away on to the floor preparatory to the next operation

It happens occasionally that the mould, when rammed, is of such a character that it would not "hold up" whilst the box is being lifted away from the pattern, or the pattern dropped away from the mould. In this case the job is made on what is known as a turnover machine, which means that, in addition to perhaps ramming the sand,

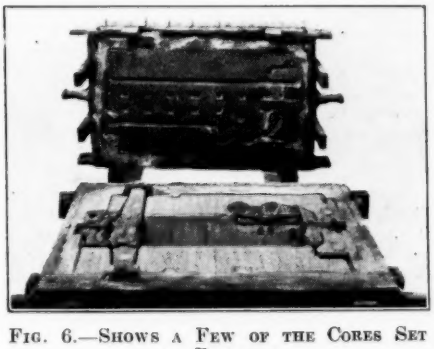


FIG. 6.—SHOWS A FEW OF THE CORES SET IN POSITION.

the machine turns the mould completely over before withdrawing the pattern. By this means that portion of the mould which would not otherwise "hold up" is not left hanging, but is being supported by the main body of sand in the box and, furthermore, the force of gravity now aids the sand to leave the pattern without breaking whilst it is being withdrawn. The same process is applied to the making of cores, only in this case the sand is rammed into the corebox and the core then turned out on to a flat plate. There are, of course, very many different types of machines on the market, each having their own particular methods of operation and advantages,

XUM

but the principles described above apply to all of them.

Aluminium.

One of the most important metals used for castings in the modern automobile is aluminium. Although this is a metal which has only been used commercially to any large extent during the past twenty years, the progress which has been made in its adaptation for motor-car work is remarkable.

Aluminium, in its pure state, is not used for making motor castings, except in very rare instances, the reason for this being that pure aluminium has a comparatively low tensile strength, and is, moreover, somewhat difficult to cast successfully. The pure metal is therefore alloyed with some other metal or metals (generally zinc, or copper, or both) in order to improve the strength and make casting easier.

There are a large number of different alloys of aluminium and other metals, each having their own peculiar properties and particular uses. Amongst the better known of these alloys are the following:—

(i) *L5 Alloy*, containing approximately 85 per cent. aluminium, 2½ per cent. copper and 12½ per cent. zinc.

(iii) *L11 Alloy*, containing 91.75 per cent. aluminium, 7 per cent. copper and 1.25 per cent. tin.

(iii) *L8 Alloy*, containing 88 per cent. aluminium, 12 per cent. copper.

(iv) *L24 Alloy*, containing 92.5 per cent. aluminium, 4 per cent. copper, 2 per cent. nickel and 1½ per cent. magnesium.

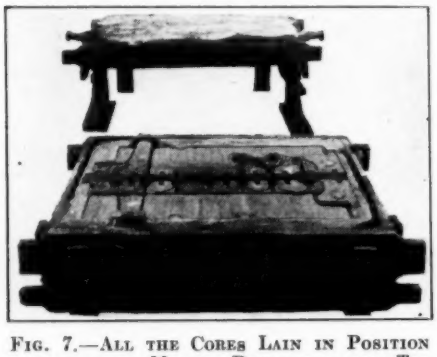


FIG. 7.—ALL THE CORES LAIN IN POSITION WITH THE MOULD READY FOR THE TOP PART TO BE PLACED ON.

(v) *Aluminium-silicon alloy*, containing from 5 to 13 per cent. of silicon, the balance being aluminium.

The magnesium alloys—containing up to 10 per cent. of magnesium, with the balance of aluminium

The L5 alloy, with variations in the copper and zinc contents, is generally used for such aluminium castings on the car as crank-cases, gear-boxes, oil sumps, etc. This is a strong metal, readily machinable, not too difficult to cast, and can be recommended as a good all-round aluminium alloy.

The L11 alloy, although not so tough nor giving quite so high a tensile strength at normal temperature as the previous alloy, is used for such castings as cylinders, which have to withstand stresses at fairly high temperatures. The reason for this is that the tensile strength of this metal at these temperatures is better than that of the L5.

The L8 alloy, together with the L24, is the most commonly used for pistons, although occasionally it is also used for cylinder work.

The alloys of silicon and aluminium (which form the subject of several patents) are claimed to have (1) a higher tensile strength; (2) greater ductility; (3) closer grain; (4) more fluidity; and (5) a lower specific gravity than L5. The first three benefits, however, are only obtained after treating the molten metal either with metallic sodium or some sodium salt (*e.g.*, sodium fluoride) which will decompose on introduction into the metal and deposit sodium. It is also claimed that this alloy, owing to its great fluidity and low shrinkage, is easier to cast than the usual aluminium alloys. This claim, in the author's opinion, has yet to be substantiated. One thing, however, is certain, and that is, that with correct treatment or modification, as it is called, a strong, tough metal with a wonderfully close fracture is obtained. The low specific gravity of this alloy offers a considerable advantage where the weight of the casting is of importance, as in aero-engine work. This metal, however, is not so easy to machine as, say, L5 or L11, owing to the decided tendency to drag, which it possesses.

Melting.

As aluminium and its alloys melt at a fairly low temperature (about 650 deg. C.), the general practice is to melt it in crucibles. These are sometimes made of plumbago, but more usually of cast iron. The furnaces used are either tilting (to pour into the conveying crucibles) or of the fixed type sunk into the floor. In the latter case the metal is ladled from the melting crucibles into the carrying pots. The furnaces are heated either with coke, producer gas, town gas, or crude oil, using air under pressure. The maximum temperature required is not usually over 800 deg. C. The pure metal is received in notched bars or ingots, and when melted the addition of metals with lower melting points than aluminium (*e.g.*, zinc, tin, etc.) is a simple matter. These additions are made by dissolving them in the molten aluminium.

When, however, it is necessary to alloy metals of a higher melting point than aluminium (*e.g.*, copper), a different procedure is necessary. Two methods are in general use. The first is to melt a known quantity of copper (*e.g.*, 100 lbs.) in a crucible, and when this has melted and is fairly fluid, pure aluminium is added a little at a time until an equal quantity of aluminium has been added to the copper. It is, of course, important that the aluminium should not be added too quickly, otherwise the metal would set into a solid mass. As soon as all the aluminium has been added, the metal is thoroughly stirred and poured into ingot moulds. This gives an alloy containing equal parts of aluminium and copper, which has a fairly low melting point, and will dissolve in pure molten aluminium, so that once having this alloy made it is an easy matter to add any desired percentage of copper to the aluminium. The second method of producing this alloy is to melt in separate crucibles copper and aluminium in the proportions of two parts of aluminium to one of copper. As soon as the copper is thoroughly melted, the pot is lifted out and the molten copper poured into the aluminium; the resulting metal is thoroughly mixed and poured into ingot moulds, giving a rich alloy of copper and aluminium containing about 33.3 per cent. copper.

Moulding.

Most aluminium castings are made in green-sand moulds; that is to say, the moulds are not baked in a stove until perfectly dry. It is usual, however, to skin-dry the moulds by means of a gas torch or blow pipe. As soon as the pattern has been withdrawn from the sand, the mould is dusted or brushed over with finely-powdered French chalk. The object of this is to give the surface of the mould a smooth finish and enable the sand to withstand the eroding action of the metal, thus imparting a smoother appearance to the casting.

When preparing moulds for aluminium castings it is necessary to allow runners of larger area than is customary with most other metals, owing to the fact that aluminium sets very rapidly, and in consequence the mould must be filled with metal as quickly as possible. Also it is *essential* with castings of any size to provide fairly heavy risers or feeders for the purpose of counteracting the effect of the liquid shrinkage during the setting of the metal, otherwise "draws" and spongy places will ensue. In some cases chills are used for this same purpose. These are pieces of iron or gun-metal shaped as required, which are placed in the mould where the heavy sections occur.

Whilst there are many causes of defects in aluminium castings, which are too numerous to mention here, it may be desirable to enumerate one or two of the most important.

Perhaps the most frequent trouble experienced in aluminium castings during machining is the

presence of blow-holes. These are nearly always due to a scum or oxide film which forms in the metal during the process of casting. Immediately the molten metal enters the mould and comes in contact with the relatively cool surface therein, a film of oxide or rubbish is formed, which, unless adequate precautions are taken, remains in the casting. This scum or rubbish is the chief cause of blow-holes in aluminium castings. The principal methods of overcoming this difficulty which are employed are (1) to pour the casting with the mould as hot as circumstances render practicable; (2) to provide adequate risers or scum-heads, if

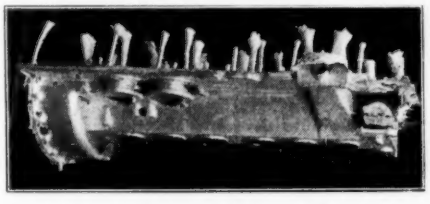


FIG. 8.—SHOWS THE CASTING JUST AS IT LEAVES THE MOULD.

possible, wherever the oxide is likely to lodge. The position of these can only be decided upon by experience or after repeated tests. Another common defect found in aluminium castings is the presence of porous places, or "draw-holes," as they are technically termed. These generally occur where heavy sections of metal adjoin thin ones, and are caused by the shrinkage of the metal. For instance, assuming that in an aluminium casting of fairly uniform thickness (say, 3-16 in.) there are several very heavy bosses adjacent to thin walls, the following action will take place. Immediately the mould is filled with metal the thin sections cool and commence to shrink until set; meanwhile, however, the heavy bosses are still in a liquid or semi-liquid condition, and therefore the metal "feeds" from these heavier portions to take up the shrinkage which has occurred in the thin sections. This means that when the heavier sections in their turn set, they are deficient in metal, and consequently open or porous places are produced either in the bosses themselves or closely adjoining them.

Aluminium and its alloys contract considerably in cooling from the molten state to the normal temperature, and a casting is approximately 1.25 per cent. (actually 1 in 77) smaller than the mould from which it is made. This contraction plays an important part in the manufacture of aluminium castings, as, owing to the fact that the metal is very weak at a temperature just below its melting point and the contraction is so great, very careful provision has to be made to ensure that the mould and cores producing the casting *will yield easily* to the pressure exerted by the contraction. Should the mould and core be too solid, the casting inevitably cracks. It is largely on this account also that aluminium castings are removed from the mould as soon after casting as possible, in order to free the cores and allow the casting to contract evenly.

Figs. 3 to 9 show the various steps in the manufacture of a crank-case casting.

Defects.

There are many defects which have to be overcome by the aluminium founder in the production of his castings, and whilst space does not permit of enumerating all of these, attention might well be drawn to three of the more general ones. These are:—(i) Draw-holes and cracks; (ii) blow-holes; and (iii) inaccurate castings.

Draw-holes and cracks, as mentioned previously, are due mainly to shrinkage, whilst the blow-holes are caused either by oxidation of the metal or by gases generated by the heat of the metal from the sand forming the cores and mould. Inaccurate castings are, of course, quite apart from these, and whilst this trouble is more obvious, the founder is often asked to make castings which are really not practicable propositions, owing to the fact that it is frequently impossible to locate the cores with any degree of security through lack of adequate core supports. The designer could be of great assistance to the aluminium founder if particular attention were paid to some of the following points:—

(i) Very uneven sections of metal should be avoided and, more particularly, the practice of joining heavy lumps of metal to thin walls of castings. Where strength is aimed at, this could often be obtained more effectively by strengthening and bracing the parts than by thickening the metal.

(ii) Sharp corners and deep narrow pockets which are awkward to fillet are inadvisable.

(iii) Ample radii should be allowed in all sharp corners whenever possible.

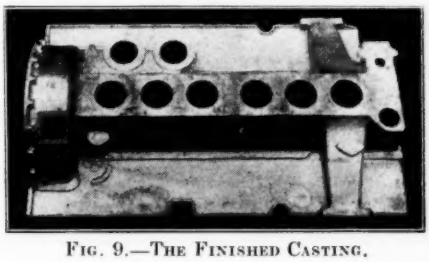


FIG. 9.—THE FINISHED CASTING.

(iv) Adequate provision should be made for supporting cores. The founder is often asked to support a large top-heavy core on a single print with a narrow base, and is blamed if this core moves. Three-point suspension is always the best, and although it is often impossible to embody this, the provision of even one extra print would considerably simplify matters.

(v) Outstanding projections from the main body of the casting, which necessitate loose pieces, frequently cause trouble and expense, and wherever possible these should be avoided.

(To be continued.)

Contracts Open.

Belfast, February 26.—3,000 galvanised-steel bins for house refuse, for the Improvement Committee. The City Surveyor, City Hall. (Fee, £1 1s., returnable.)

Kippax and Allerton, February 23.—For providing and laying cast-iron water pipes, with valves, hydrants, etc., for the Tadcaster R.D.C. Mr. H. M. Driver, surveyor to the Council, Garforth, near Leeds.

Chelmsford, February 23.—For supplying and fixing belt-driven air compressor and an overhead driving shaft, with other incidental work, for the R.D.C. Mr. J. Dewhurst, engineer, Waterloo Lane, Chelmsford.

London, N., February 25.—Two electric dust-collection vehicles, fitted with steel tipping bodies, for the Islington Borough Council. The Superintendent, Cleansing Department, Liverpool Road, N.1.

Types.

The foundryman that knows not, and knows not that he knows not,
Is a fool—shun him.

The foundryman that knows not, and knows that he knows not,
Is a child—teach him.

The foundryman that knows, and knows not that he knows,
Is asleep—wake him.

The foundryman that knows, and knows that he knows,
Is a wise man—FOLLOW HIM.—*(Arabian Proverb.)*

Iron and Steel in Chile.—A Reuter's cable from Santiago (Chile) states that the attempts made by German firms to establish an iron and steel industry in Chile appear to have failed so far, the native capitalists and owners of ore deposits having decided to take steps to create an organisation themselves for the production of iron and steel.

Trade Talk.

THE LION ENGINE COMPANY, LIMITED, have removed to 166, Pentonville Road, London, N.1.

REID, MEEKING & COMPANY, 4, St. Mary Axe, London, E.C.3, have been appointed agents for Ernest & Edmond Lisse, machine tool makers, Louvroil-lez-Maubeuge, Nord, France.

HARLAND & WOLFF, LIMITED, have issued instructions for the resumption at Belfast of the building of the 30,000-ton liner "Statendam." Work on the vessel has been suspended for twelve months.

A REPORT ON THE MARKET for wrought-iron tubes and fittings in Denmark has been prepared by the Department of Overseas Trade from information received from the Commercial Secretary at Copenhagen.

THE FEDERATION OF ENGINEERING AND SHIPBUILDING TRADES has lodged with the Shipbuilding Employers' Federation a national application for an advance in wages of 10s. per week for shipyard workers.

COX & DANKS, LIMITED, have concluded arrangements with the Admiralty for the raising of the greater number of the German warships which were scuttled at Scapa Flow on June 21, 1919. Operations will be commenced about the end of March.

THE STAVELEY COAL AND IRON COMPANY, LIMITED, near Chesterfield, have appointed Mr. T. A. McKenna as their London representative for the sale of pipes and castings, and he will be in charge of the company's London office at 34, Victoria Street, Westminster, S.W., from the 1st prox.

MEMBERS OF THE Institute of Metals (Birmingham section) took part in a discussion, last week, on the subject, "Waste Products and Losses in the Non-Ferrous Metal Industry." The chairman (Dr. Johnson) initiated the discussion, which was participated in by Dr. Brownston, Mr. R. Reading, and Mr. W. R. Barclay.

THE NEW monthly ascertainment price of Cumberland hematite pig-iron, mixed numbers, is just over £5 1s. 1d. per ton. The wages of the miners for the ensuing month will be as follows:—Miners working bargains, 10s. 1d. per day; miner's minimum, 7s. 5d.; winding-engine men, 8s. 9½d.; joiners and blacksmiths, 9s. 2d.

AT A JOINT CONFERENCE of employers and employed in the electrical trades throughout England, Wales, and Northern Ireland, held in Manchester, an agreement was reached to advance wages by three-halfpence an hour in three out of four zones, and a penny an hour in the remaining zone. The new rates will come into force on March 1. The new wages range from 1s. 4¼d. to 1s. 10d. per hour.

PLANS for the new railway bridge across the Murray River at Murray Bridge, estimated to cost £250,000, have been approved by the South Australian Minister of Railways, and tenders will probably be called for the work at the end of February. The plans provide for a bridge entirely of steel, about 1,800 feet long. The new structure, which will have a slight curve, will comprise three main spans across the water—one of 240 feet and two of 145 feet each.

MR. E. J. GEORGE, general manager of the Consett Iron Company, Limited, speaking at a gathering at Blackhill, made an important reference to the future development of Consett and its works. He remarked that the Consett Iron Company was going through a long period of preparation, with regard to the reconstruction of the steel works and the development of the coke-making industry. They were just beginning to see their way to put in operation the adventurous schemes they had undertaken and still had in hand. He was hopeful that the town would become very much larger and more prosperous than it had been. He was speaking in Benfieldside parish, and he sincerely trusted that before many years the whole place would be known as the Consett district, and that they would have a much larger group of Councils under one central body.

THE LONDON MIDLAND AND SCOTTISH RAILWAY COMPANY has placed contracts for machine tools, etc., with the following, among other, firms: Alfred Herbert, Limited, Coventry; Webster & Bennett, Limited, Coventry; James Archdale & Company, Limited, Birmingham; Tangyes, Limited, Birmingham; General Electric Company, Limited, Birmingham; S. Platt, Limited, Wednesbury; F. Pollard & Company, Limited, Leicester; Wadkin & Company, Leicester; Ewart, Chambers & Company, Derby; A. Ransome & Company, Limited, Newark; Craven Brothers, Reddish; Brightside Foundry and Engineering Company, Sheffield. These orders are for new equipment for the company's various workshops. Contracts for 100 locomotive boilers have been divided between Ruston & Hornsby, Limited, and Beyer, Peacock & Company, Limited; while the International Construction Company, Limited, have the contract for a new gas-producing installation at Crewe.

Correspondence.

[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]

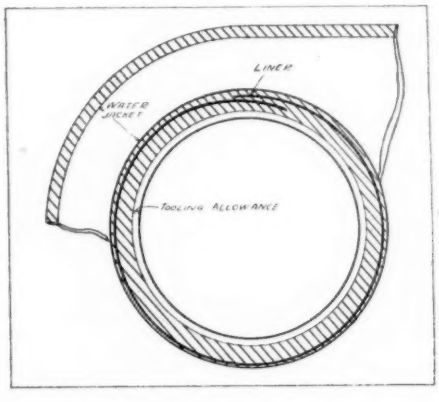
Reinforced Cast Iron.

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—I was interested in your note on "Reinforced Cast Iron" as applied to the making of automobile cylinders in your issue of February 7, and having had considerable experience (and encountered many difficulties) in the making of these castings I should like to offer a little criticism of this process.

I have inspected a number of these armoured cylinders and I invariably found that the liners do not actually touch the insides of the barrel portions of the jacket cores as indicated, but appear as shown in the illustration.

It is impossible to get the liners and the metal of the cylinder bores to properly knit all over due to varying temperature of the metal in different parts of the cylinder at the moment of casting. If the metal is sufficiently hot in one place it will be too hot in others and thus burn away the liner and perhaps leave other parts improperly



united. It would appear that this condition of affairs must of necessity exist irrespective of where the metal enters the mould.

To make liners to fit the intricate shapes of the cylinder shown in the sketch would entail considerable expense both in the actual making of the liners and also in the necessary tools.

It seems inconceivable that a comparatively thin steel sheet applied to the outside of the metal of a cylinder bore—probably ⅜ in. thick in the casting—can have any appreciable densening effect on the iron, even to the depth of 3-32nd in. as stated.

It would seem difficult, if not impossible, satisfactorily to "run" the thin jacket portions where they join the barrels. If this *is* accomplished, one would expect to find very serious planes of weakness in these places, even under the most favourable conditions of casting temperature and liner thickness.

I think we shall all agree that the process is in the nature of a makeshift to cover up foundry difficulties due to faulty design, imperfect cores, improper venting of mould and cores, etc., also in no small measure to our imperfect knowledge of the metallurgy of cast iron.

There is doubtless a growing tendency for the designer to consult the foundry expert in the very early stages during the design of a new engine. This is a healthy sign and one to be encouraged in every possible way; it should also suggest to us an alternative to the use of palliatives. If the designer is prepared to approach the foundryman for information, let the foundryman be equally open and state frankly what his difficulties are. If this is done in the early stages before expensive patterns and tools are made, design can often be modified without sacrifice of efficiency in the finished product.—Yours, etc.,

WM. J. MOLINEUX, M.I.B.F.

(Foundry Manager, W. H. Dorman & Company, Limited, Stafford.)

WABANA IRON ORE

USE BRITISH EMPIRE ORES
FOR MAKING BRITISH PIG-IRON

Direct shipments to British Ports now arriving.
Smelted alone gives good foundry iron.
Mixed with low-phosphorus ores it makes a useful basic pig-iron. Low percentage of fines.

Write for analysis and particulars of prices and shipments to :

THE BRITISH EMPIRE STEEL PRODUCTS Co. Ltd.
Scotia House, 110, St. Martin's Lane, LONDON, W.C.2

Telephone : 21, Penistone. Telegrams : "Durranns, Penistone."

ESTABLISHED 1863.

JAS. DURRANS & SONS., LTD.

Phoenix Works, Penistone NEAR SHEFFIELD.

BLACKING
PLUMBAGO
CORE GUM
WHITE DUST
COAL DUST

Manufacturers of

FOUNDRY EQUIPMENTS.

Ladles, Cupolas, Fire Bricks, Ganister, Stone Flux, Loam and Sand Mills, Casting Cleaners, Studs, Chaplets, Pipe Nails, Sprigs, Brushes, Wire Brushes, Core Ropes, Bellows, Buckets, Spades, Forks, Riddles, Sieves, Barrows, Etc.

Write for illustrated catalogue on Blacking and Foundry Requisites, also for our latest Price List.

IRON AND STEEL MARKETS.

Pig-iron.

MIDDLESBROUGH.—The position of the Cleveland iron market, as previously reported, has certainly not been improved by the week-end developments of the dockers' strike movement, which it is feared will result in a serious set-back to the expansion of trade so urgently needed in all branches of industry. As was anticipated, an immediate consequence of the dockers' action is a curtailment of production at the blast furnaces, reducing the number in operation on Cleveland pig-iron to 14, while further restriction of output must necessarily follow, as makers cannot afford to carry stocks at the high prices now ruling, and export trade must practically be completely suspended until the strike is settled. In the circumstances prices indicate further weakness, another sixpence having been knocked off the standard No. 3 Cleveland G.M.B. quality, and the quoted figure of 97s. could possibly be still further shaded for a good order. Other qualities were not quotably reduced, but transactions just now are a matter of arrangement, and quoted prices only an approximate guide. No. 1 is nominally 100s. per ton; No. 4 foundry, 95s.; and No. 4 forge, 94s.

Some of the hematite makers still have a considerable tonnage to deliver under old contracts, but they are not getting new business as they would like, and the position is one of growing anxiety. Prices are drooping, but makers are in no hurry to cut prices till they see a chance of business. Meanwhile, the quoted rate for East Coast mixed numbers is 101s., and for No. 1 102s. In the North-West area Bessemer mixed numbers remain at the old quotation of 115s. per ton delivered at Glasgow and Sheffield and 120s. at Birmingham.

MANCHESTER.—Stagnation in fresh buying continues unrelieved in this district, but many foundries having bought freely for forward delivery at the end of the year are not in any hurry to extend their commitments. Sellers of Derbyshire No. 3 foundry iron are still quoting 102s. 6d. per ton for delivery in Manchester, and some small business is passing at this figure. The demand for Scotch iron is not large here, and although the prices are relatively much easier than they were there has been no great increase in consumption.

THE MIDLANDS.—On the Birmingham market last week business in foundry pig-iron was quiet, but supplies of all No. 3 quality were obtainable quite readily, although it is still very difficult—almost impossible—to get certain brands of Derbyshire and Northants No. 1 grade. Ruling prices of pig-iron, f.o.t. furnace, are as follow:—Derbyshire No. 3 foundry, 95s.; Staffordshire No. 3 foundry, 92s. 6d. to 95s.; Northants No. 3 foundry, 92s. 6d. to 93s. 6d.

SCOTLAND.—Movements in the Scottish pig-iron market continue restricted in scope, and in consequence prices are easier, with No. 3 foundry quoted at 102s. 6d. per ton f.o.t. furnaces. Most of the consumers are still fairly well bought, and where this is not the case a hand-to-mouth policy is being adopted, while there is keen competition for what orders do come into the market.

Finished Iron.

The recent distribution of substantial orders for railway rolling stock has greatly stimulated business in the finished-iron section, and most of the works in South Staffordshire are fairly well employed, although specifications for the general trade and for ordinary qualities are yet on the quiet side. The prices have not altered in any way except that the makers of nut and bolt iron are sticking out for £11 5s. and up. The Continental price for this class of iron has shown an upward tendency, the lowest figure now being £8 17s. 6d. per ton delivered station Birmingham and district for delivery 8-14 weeks. The difference in price is still a large one, and those orders for which the bolt makers can wait three to four months will continue to go to the Continent. English marked bars are £14 10s. f.o.t, with £12 10s. net, delivered station, the price for ordinary crown bars.

Steel.

As has been recently reported, Continental competition in the home steel markets is steadily increasing, and although deliveries are likely to be delayed by labour troubles at the various ports of entry tempting offers of material are in circulation on forward account. Incidentally, the Welsh makers have practically ceased rolling billets, largely on account of competition abroad, while the prices they have been able to command, viz., £7 5s. to £7 10s., have not covered the cost of production. Business in ferro-manganese is of very small dimensions, but prices are maintained so far. The phenomenal advance in quotations for tin may possibly lead to an increase in the minimum prices of tinplates, which are already a shade harder, whilst second-hand parcels are now scarcely obtainable at 24s. basis, I.C. f.o.b.

Scrap.

The markets for scrap metal show little improvement since last reported, while any increased activity in movements will undoubtedly be adversely affected by existing labour troubles. The demand for cast-iron scrap from the Lancashire foundries is still very poor. For good heavy machinery cast scrap the price seems to vary from 87s. 6d. to 92s. 6d. per ton, according to position. Possibly up to 95s. may sometimes be obtained for metal from textile machinery, but there is not much of this business to be done. The Scottish foundries are still getting in good supplies of Continental pig-iron, and except in cases where this material is unsuitable the quantity of scrap being used is small. It is reported that machinery metal has been sold at 97s. 6d. per ton, but this may have been for a small quantity only for prompt delivery. Generally speaking, the price for machinery metal and cast-iron rail way chairs runs about 100s. Ordinary cast-iron scrap runs about 90s. to 92s. 6d., according to quality. Light metal and furnace firebars are at 75s.

Metals.

Copper.—The market for standard copper last week-end disclosed unexpected strength, but it is regarded as doubtful whether this firmness in values will continue for long, although the metal is peculiarly subject to occasional eccentric fluctuations. Notwithstanding, however, the fact that world production is probably still in excess of consumption, the general outlook is fairly encouraging, for metal is being used up in America at quite a good rate, and Europe, if not able to buy as much as it would be able to under more normal conditions, is nevertheless absorbing quite substantial tonnages. Current quotations:—*Cash*: Thursday, £63 10s.; Friday, £64 15s.; Monday, £66 2s. 6d.; Tuesday, £64 5s.; Wednesday, £64 2s. 6d. *Three Months*: Thursday, £64 7s. 6d.; Friday, £65 12s. 6d.; Monday, £66 17s. 6d.; Tuesday, £65 2s. 6d.; Wednesday, £64 17s. 6d.

Tin.—Considerable excitement was evidenced at Thursday's market, when the cash price of standard tin was advanced to £280 15s. per ton at the close. The forward quotation rose £5 15s. to £277 10s. per ton. Thus, new records have been established in the present upward movement, with cash tin £30 up on the month. Current quotations:—*Cash*: Thursday, £280 15s.; Friday, £281; Monday, £284 15s.; Tuesday, £280; Wednesday, £275 17s. 6d. *Three Months*: Thursday £277 10s.; Friday, £277 15s.; Monday, £281 10s.; Tuesday, £276 15s.; Wednesday, £272 17s. 6d.

Spelter.—Rudolf Wolff & Company report that demand on the part of consumers continues slow, but on the other hand producers evince little desire to sell at current prices. There is at the moment no very decided tendency, and until fresh developments arise it seems probable that fluctuations will be confined within narrow limits. Current quotations:—*Ordinary*: Thursday, £36 10s.; Friday, £37; Monday, £37 8s. 9d.; Tuesday, £37 7s. 6d.; Wednesday, £36 15s.

Lead.—The market for soft foreign pig continues firm, with values again advanced, and conditions are unlikely to be changed in the near future while uncertainty exists with regard to incoming shipments from abroad. Current quotations:—*Soft foreign (prompt)*: Thursday, £34 5s.; Friday, £34 12s. 6d.; Monday, £35; Tuesday, £35; Wednesday, £34 15s.

Patent Specifications.

Particulars of Complete Specifications Accepted, furnished by Mr. Eric Potter, Patent Agent, of 27, Chancery Lane, London, W.C.2. Printed copies of the specifications in the following list are now on sale.

210,546.—KEAY, R. W. Foundry moulding-machines.
210,583.—BEARDSLEY, E. O., and PIPER, W. F. Foundry moulding-machines.
210,652.—WILD, L. D., and BARFIELD, E. P. Electric furnaces.